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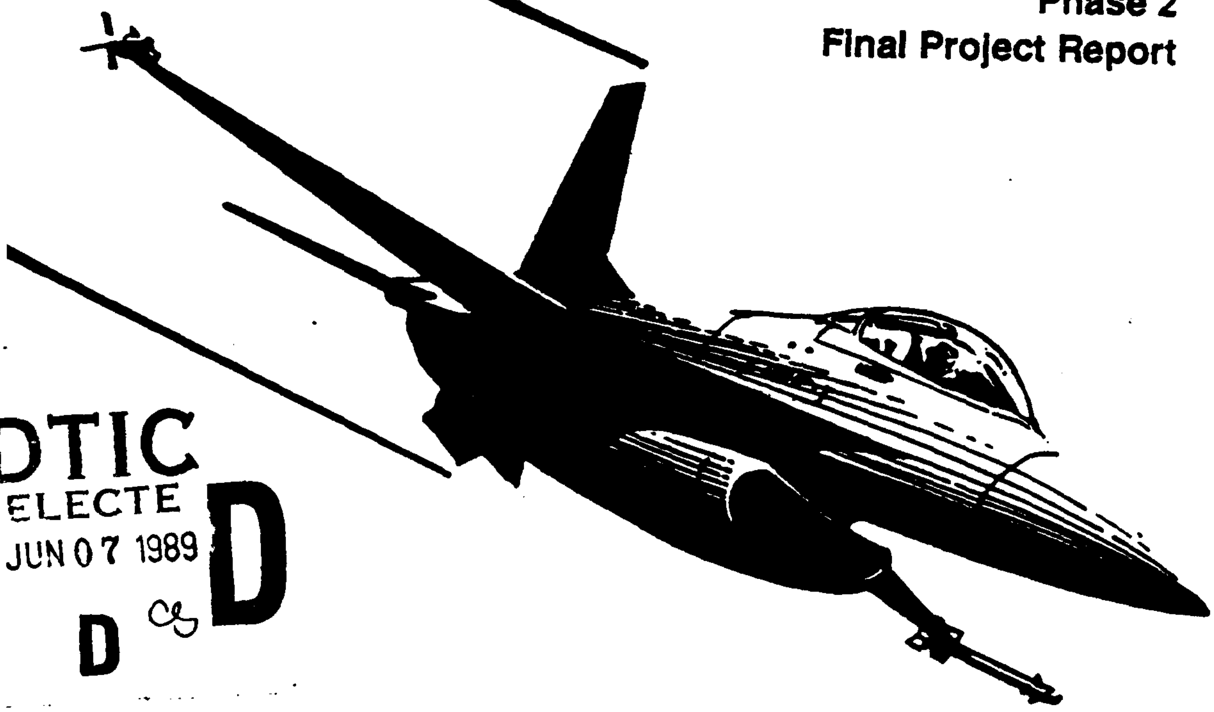
GENERAL DYNAMICS

FORT WORTH DIVISION

INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM

Phase 2

Final Project Report



PROJECT 80

INCREASE EFFICIENCY OF CARD TEST/DEVICE TEST AREAS BY THE USAGE OF IMPROVED MATERIAL HANDLING SYSTEMS

REVISION 1

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This project addresses modernization of the printed circuit card test and final device assembly and test areas within the Flight Management and Targeting Systems Department. This task is to be accomplished through more efficient use of floor space, utilization of automated storage and retrieval systems, consolidation of printed circuit card testing, streamlining work flow, and installation of ergonomically designed work cell/work centers. Incorporation of these changes will result in increased productivity and test yields brought about by a reduction in rework, training, and throughput time.

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GENERAL DYNAMICS
FORT WORTH DIVISION

INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM

PROJECT 80 REVISION 1

PHASE 2 FINAL PROJECT REPORT
INCREASE EFFICIENCY OF CARD TEST/DEVICE TEST AREAS BY THE USAGE OF IMPROVED MATERIAL HANDLING SYSTEMS

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PROJECT 80

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PROJECT 80

INCREASE EFFICIENCY OF CARD TEST/DEVICE TEST AREAS BY THE USAGE OF IMPROVED MATERIAL HANDLING SYSTEMS

SECTION 1

INTRODUCTION

The Flight Management and Targeting Systems (FM & TS) Production is chartered to manage and produce a variety of fixed and rotary wing aircraft electronics in support of the Flight Systems Operation (FSO).

The mission of FM & TS Production is to generate revenue and profit by executing production contracts in support of FSO profit and ROI objectives. FM & TS products are typically low volume, high technology devices built under specific customer contracts.

The Flight Management Area produces flight control systems for fixed and rotary-wing military aircraft for various customers. While the function of each of the systems is relatively similar in nature, each system is unique in the functions controlled on the aircraft, the quantity of devices (black boxes) which make up the system, as well as the specific customer build and test requirements.

As a rule, the component devices for a system are required to be interchangeable from one system to another and are therefore tested and shipped to the customer as individual devices. Most of these devices consist of a chassis into which printed circuit cards and other sub-assemblies are inserted to form a functional black box. The various devices contain from 10 to 25 printed circuit cards and are produced in relatively low quantities. Other devices which are part of the systems may contain fewer than 3 printed circuit or similar type devices and are also produced in low quantities.

The Targeting Systems Area produces an advanced helmet mounted sighting and display system. This system consists of several component devices which require unique skills to produce. Two of the "black boxes" are similar in nature to those described above for the Flight Management Area and require similar assembly and test techniques. However, the remaining component devices are unique to FM & TS.

The display system utilizes a miniature cathode ray tube mounted on the pilot's helmet and requires precise assembly and test of optical and electronic devices. The sighting system consists of several components precisely

mounted on the helmet and other sensor units which are mounted in the aircraft cockpit. These units also require unique assembly and test skills with very tight controls. As with the Flight Management Area, these systems are produced in relatively low quantities.

Project 80 was initiated to provide increased efficiency by the use of material handling and production flow improvements in the Card and Device Test areas within FM & TS. These improvements include:

- Flight Management Area
  - Vertical Storage and Retrieval System Material Storage Units
  - Ergonomic Workstations
  - Area Consolidation
  - Area Relayout by Product Orientation
  - Redistribution/Reduction of Group Leader and Production Control Efforts
- Targeting Systems Area
  - Vertical Storage and Retrieval System Material Storage Units
  - Ergonomic Workstations
  - Area Relayout Incorporating Process Orientation
  - Redistribution/Reduction of Group Leader and Production Control Efforts

These additional improvements implemented under Project 80 will provide FM & TS with a significant increase in the efficiency of their manufacturing and help to reduce their overall manufacturing costs.

SECTION 2

PROJECT PURPOSE/OVERVIEW

The following section presents an overview of ITM Project 80. An overview of the FM & TS Production department and their primary objectives is also presented along with a brief description of the Tech Mod efforts at Honeywell.

2.1 FM & TS Overview

Flight Management and Targeting Systems (FM & TS) Production is chartered to manage and produce a variety of fixed and rotary wing aircraft electronics in support of the Flight Systems Operation (FSO).

The mission of FM & TS Production is to generate revenue and profit by executing production contracts in support of FSO profit and ROI objectives. FM & TS products are typically low volume, high technology devices built under specific customer contracts. The FM & TS Production organization directly provides Production Engineering, Production Control, and operating capabilities to manage and execute production programs, support engineering programs, and provide specialized services to other product areas. Quality, Logistics, Procurement and Manufacturing Technical Services support is provided to FM & TS Production by Honeywell's Military Avionics Division (MAvD) central organizations.

The priority objective within FM & TS Production is to produce quality products within cost goals. Additional objectives include flexibility and dependability with the emphasis differing slightly in each of the focused factories.

2.2 FM & TS and Tech Mod

The USAF Tech Mod program was instituted to provide strategic planning and develop facility modernization projects that reduce manufacturing costs, improve product quality and reliability, and reduce manufacturing throughput time. In addition, the Tech Mod program has been chartered with assuring the capability for a rapid increase in production in the event of national emergency.

Under the guidance of the Tech Mod program, Honeywell has defined several areas for improving production in the Flight Management and Targeting Production facility in St. Louis Park, Minnesota. ITM Project 80 has been initiated with the purpose of upgrading the FM & TS Card/Device Testing areas and is described in the following section.

2.3 Project 80 Strategic Goals and Objectives

FM & TS Production has defined several major objectives that are being incorporated in their future business planning. These objectives include increasing the flexibility of their operations and improving product quality, while maintaining a high degree of cost control.

Cost control is the overriding objective of FM & TS Production planning. This control must be maintained for both existing program production as well as for new programs. The cost control efforts underway in FM & TS Production are wide-ranging and are being applied at every level of the organization. Examples of this can be seen in the current implementation of the HMS/BOS MRPII system in St. Louis Park as well as the implementation of the Factory Data Collection System. In addition to controlling costs, the following objectives have been defined as critical to FM & TS's future production operations:

- **Increase flexibility of operations.** FM & TS will manufacture between six and ten products at any particular time and with the introduction of new programs which introduce both process and product changes, the current operations must remain flexible in adapting to these changes while still maintaining the capability of supporting existing programs.

- **Increase product quality.** By achieving 100% conformance with customer requirements, Honeywell will be viewed as the leading supplier of Military Avionics products. While this is of important strategic value from a marketing perspective, it can also have a direct effect on lowering the manufacturing costs in such areas as reducing rework and scrap.

- **Reducing production lead times.** Customer requirements dictate shorter production lead times and these will be accomplished through developing more streamlined process, material, and production flows. Improvements in information processing (such as HMS and FDC) will also aid in reducing production lead times.

ITM Project 80 has been defined by the Honeywell Tech Mod Project Team for implementation in Flight Management and Targeting Systems Production. This project, as defined by the Tech Mod Project Team, is described below.

ITM Project 80 addresses the modernization of the factory layout of the printed circuit card test and final device assembly and test areas within the

Flight Management and Targeting Systems (FM&TS) department. This modernization is to be accomplished through more efficient use of floor space, utilization of vertical storage and retrieval systems (VS/RS), consolidation of printed circuit card testing, streamlining work flow, and installation of ergonomically designed work cell/work centers. The benefits associated with the implementation of ITM Project 80 include:

- Centralized material access
- Reduction in material search time
- Increased operator productivity
- Consolidation of work areas reducing transit distances
- Elimination of reliance on stores personnel for intra-area material movement
- Arrangement of work cells for more effective product/process flow
- Overall arrangement provides for more linear flow of work through areas
- Key functions are more centrally located
- Storage equipment located adjacent to points of primary use
- Sufficient area for expansion is provided

This project represents a significant part of the overall Tech Mod program currently being administered in Honeywell's Military Avionics Division.

SECTION 3

TECHNICAL APPROACH

The following chapter describes the general approach and methodology adopted by the Project 80 team.

The first subsection describes the overall approach and methodology for performing an in-depth analysis of the FM & TS card/device test area operations and presents the methods employed in developing a structured design for more advanced operations and material handling methods. In addition, this section presents the evaluation methods used to establish technical requirements which define the possible material handling improvements within the Card/Device Testing operations.

The second subsection introduces the philosophy of developing a manufacturing operations structure by first defining hierarchical levels employed in a manufacturing environment and the characteristics of production with respect to the impact of decisions concerning product versus process orientation (or a mix of these) at each of these levels. The ITM Project 80 objectives are then described as they relate to each of the hierarchical levels defined and the variables and criteria necessary for making recommendations for each of these levels is presented. These criteria are utilized more extensively in Sections 4 and 5 in defining and developing the advanced design of the card and device test areas.

Subsection three presents the factors that affect the design of work areas (both work cells and workstations). The methodology of developing requirements for optimally designed work cells and workstations is presented along with the development of specific material handling requirements. Ergonomic design philosophies are described as they were employed in the development of the specific workstations as well as the overall area layouts and material handling designs.

The final subsection describes the approach developed for selecting material handling equipment. This includes the methodology used to develop requirements for equipment, the selection criteria, and the high level evaluation matrices.

3.1 Overview of Project Approach and Methodology

ı ıis section describes the overall approach and methodology employed in the in-depth analysis of the FM & TS Card/Device Testing operations and presents the methods used by the project team in developing a structured design for more advanced operations. In addition, this section presents the evaluation methods used to establish technical requirements which define the

areas for improvement in material handling and production flow within the Card/Device Testing operations.

The project team has developed an overall approach for performing ITM Project 80 which is summarized in Figure 3.1-1. During the initial phase of the project, this approach required the collection of a great deal of information, including:

- Project 80 Statement of Work
- Tech Mod Program Goals
- FM & TS Business
- FM & TS Products
- Personnel Interviews
- Facility Tours
- Card/Device Testing Area Existing Material Handling Methods and Equipment
- Card/Device Testing Area Existing Systems

This information was assimilated by the project team in a series of meetings designed to assure that the team fully understood the various facets of the FM & TS Card/Device Testing current operations. The analysis resulting from this exercise, along with the technological understanding of similar operations to that of FM & TS, were then utilized in developing the future material handling operations design as well as the relayout of the area to provide a more streamlined production flow, material flow, and information flow.

The final phase in this process is the development of an implementation plan which outlines the implementation steps required to achieve the final plan and a cost benefit analysis which defines the benefits in respect to the necessary investment and the time required to realize a return on Honeywell's investment.

In utilizing the approach described above, the project team has found that an iterative process methodology would yield the best results in the creative process of designing systems and operations similar to the Flight Management and Targeting Systems (FM & TS) operations. This methodology is particularly applicable in the type of environment, both from a physical perspective as well as a business and management perspective, that exists for the Honeywell project team.

In the early stages of the project, the iterative process consisted of the presentation of information collected and assimilated by the project team in a concise format. After an agreement as to the adequacy of the presentation was reached at this level, the process moved further into more detailed levels. This is the basis of the iterative process. Further iterations addressed the first initial conceptual levels of design and, as more detail was agreed upon, more precise elements of the design were put into place.

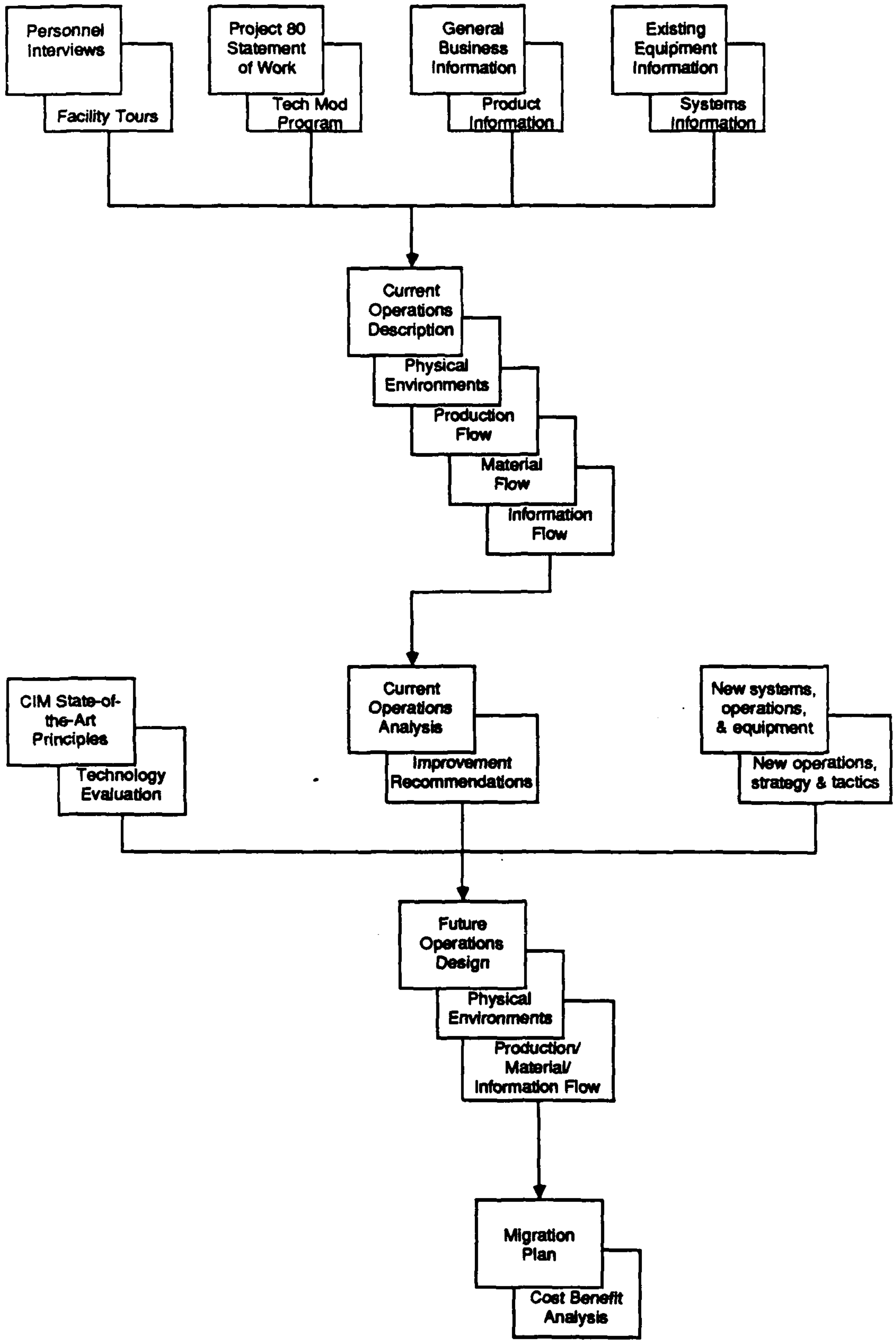


Figure 3.1-1 Project Approach and Methodology

The feedback generated as a result of each of these presentations and the incorporation of this information into the final report assures that the results of the overall design process are compatible with the desires and ideas expressed by the user's and management organization. The iterative design process is illustrated in a conceptual manner in Figure 3.1-2.

3.1.1 Operations Analysis

The goal of a comprehensive operations analysis is to first describe the current operations of Honeywell's FM & TS Card/Device Testing areas. Based upon this description, specific areas and operations are defined (in accordance with the statement of work) for further analysis as they significantly impact the direct or indirect costs of FM & TS production. This analysis then provides the foundation upon which the operations of the future is designed.

The absolute and definitive areas which are identified as cost drivers in the Card/Device Testing operations lie in a multi-dimensional space with complex interrelated dimensions that are difficult to delineate. The primary task in the analysis phase is to determine the methods and approach required to define and analyze an issue which is extremely complex. As shown in Figure 3.1.1-1, this multi-dimensional space is characterized by the hierarchical levels existing within the FM & TS organization and the specific objectives of ITM Project 80.

By specifying the general objectives to be achieved, it is possible to reduce the complexity of these interrelated dimensions and to define objectives for each of the levels of operations and analyze improvements to be made at each level. Once these objectives have been defined at a specific level, it is then necessary to establish the significant variables and criteria that will influence the analysis and recommendations made for each of these levels.

While the variables and criteria are defined more comprehensively in Section 3.2.3, they are briefly summarized as:

- Production
  - Physical Arrangement
  - Process Flow
  - Group Technology
- Material
  - Material Management
  - Material Handling
- Information
  - Systems

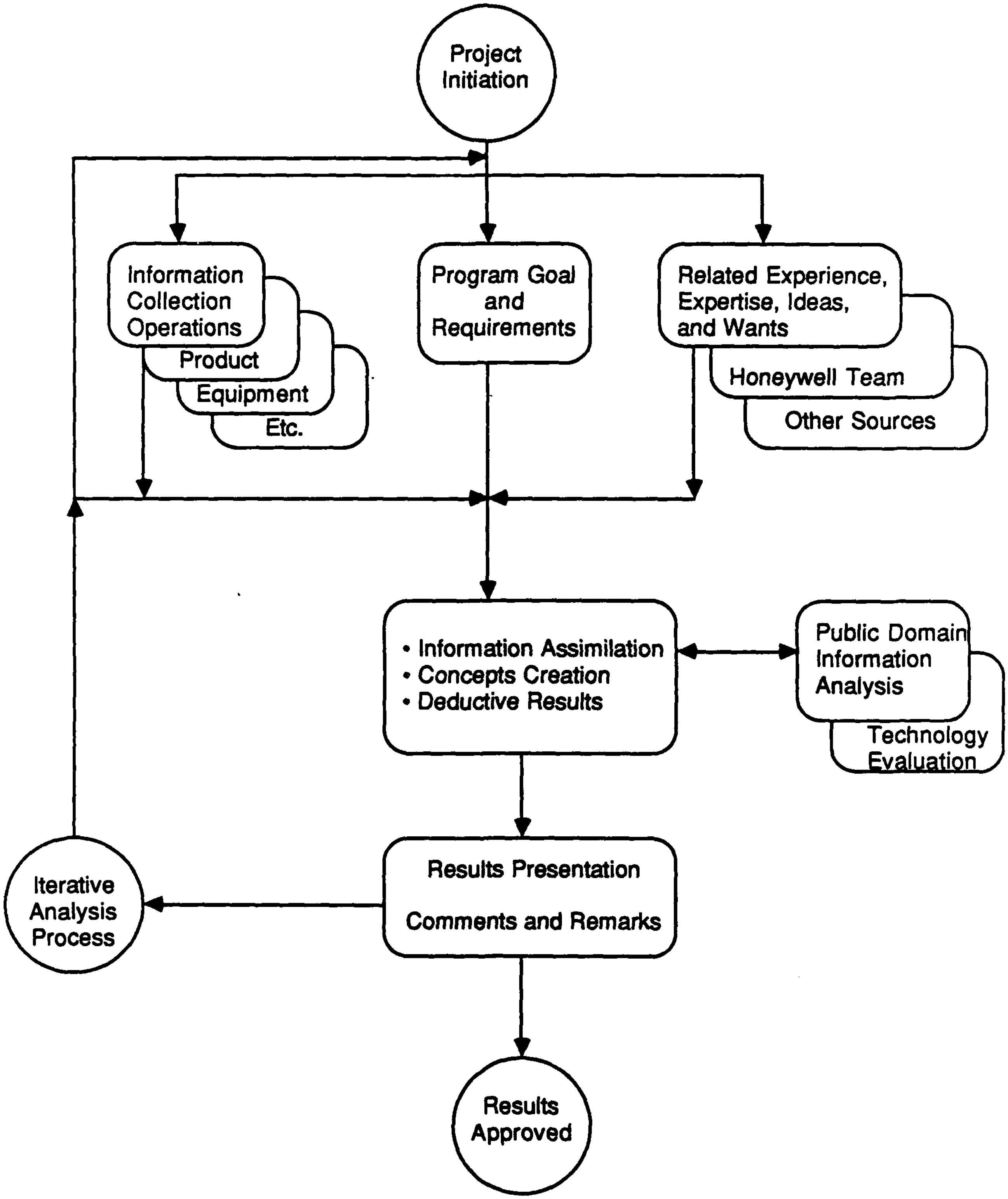


Figure 3.1-2 Typical Iterative Process

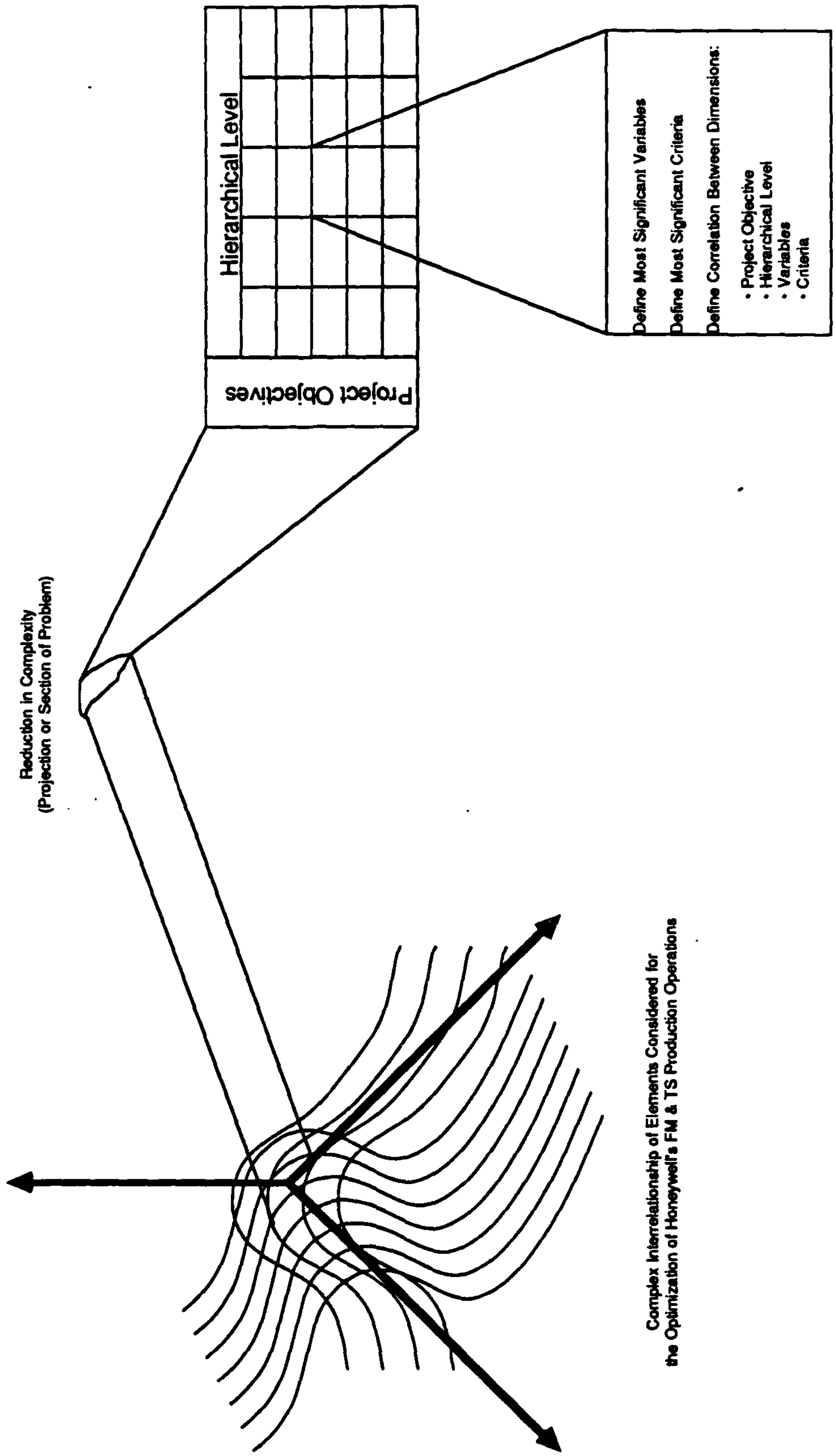


Figure 3.1.1-1 Multi-Dimensional Space Example

- Control Networks

In addition, several criteria have also been developed. These include such considerations as cost (capital investment, ROI, etc.) as well as product profiles and several other areas.

Once the project objectives have been finalized, the hierarchical levels defined, and the criteria and variables established, it is then possible to define the correlations between all of these dimensions and begin the structured design process as described in the following section and utilized throughout the progress of this report.

3.1.2 Structured Design Approach

The structured design approach employed is directly dependent upon a detailed analysis of the specific FM & TS operations for the Card/Device Testing areas. The previous section described the methodology used to approach a large, complex, interrelated structure and "break down" that structure into discrete entities (i.e., work cells and workstations). Once the operations have been analyzed at a discrete enough level to understand the processes and unique characteristics at each level, it is possible to rebuild each of the levels progressively to transform the operations into a more advanced manufacturing structure.

A general overview of this "rebuilding" process is presented in Figure 3.1.2-1. Once the analysis phase has been developed to the workstation and process level, it is then beneficial to analyze each product and discrete process in respect to Group Technology. The term Group Technology has been alternately used to describe

1) a process of codifying parts in a computer database in order to group similar parts or

2) the organization of product families into cells in order to eliminate the duplication of resources.

A codifying of all parts used at Honeywell would be an extremely large undertaking and would require the coordination of several divisions to assure its effectiveness and to realize significant cost savings. While this would be a worthwhile endeavor for Honeywell, this was not a reasonable task for the implementation of ITM Project 80. However, the project team developed matrices to define the specific miscellaneous hardware used in the Card/Device Testing areas as an aid in establishing proposed equipment and workstation requirements.

In addition, large scale matrices were developed which correlated the Honeywell part number (of each assembly, sub-assembly, and component part of all products produced by FM & TS) with the operations and the standard

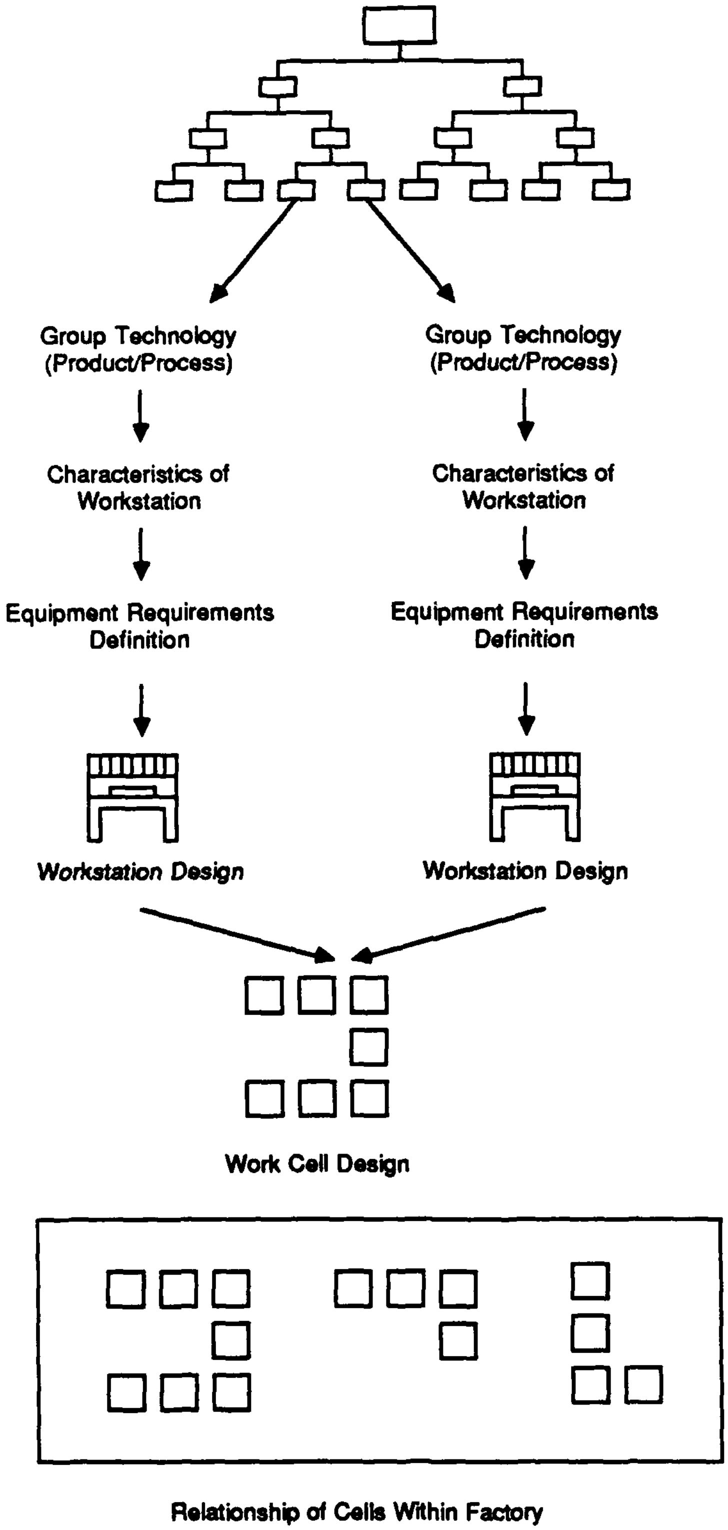


Figure 3.1.2-1 Overview of Methodology

hours required to perform these operations. These correlation matrices provided important information for grouping similar processes at workstations, defining the equipment required at each specific type of workstation as well as the actual number of workstations required for each of these groupings of operations.

In accordance with ITM Project 80, a number of other factors, which are primarily concerned with the overall area layout and the material handling requirements for these areas, have influenced the general workstation design requirements. The relationship of these factors to the overall design process are shown in Figure 3.1.2-2. The primary additional factors which also affect the design definition include:

- Production Volumes
- Material Movement and Transport Means
- Workstation Storage Requirements
- Work Area Storage Requirements

Once the design of new workstations, processes, and additional requirements for testing and other areas are defined, it is necessary to present specific technical solutions that can be implemented in the most efficient and effective manner.

3.2 Manufacturing Operations Structure

The manufacturing operations in Honeywell's FM & TS Production area have been structured both to reflect an overall Honeywell approach to divisional responsibility and in response to the changing product and production requirements. In order to develop the optimum manufacturing solutions for FM & TS production, it is necessary to "break down" the manufacturing operations structure into more discrete entities or levels that can be analyzed separately before "restructuring" the operations to provide a global alternative to their current operations.

Once these levels have been defined, a trade-off analysis can be made regarding production principles at each of these levels and for the effect the characteristics of these principles have at each of the levels and the sub-groups within these levels. The primary production principles described in this section can be defined in terms of either product orientation or process orientation.

The analysis of operations structure is applied to the specific objectives of ITM Project 80. This provides an assessment of the impact of these principles at each level addressed by the project and defines the project objectives with respect to each level.

Following the detailed definition of the project's objectives, the specific variables that influence decision making at each of the levels and the criteria that must be met to accomplish the project objectives are determined. The

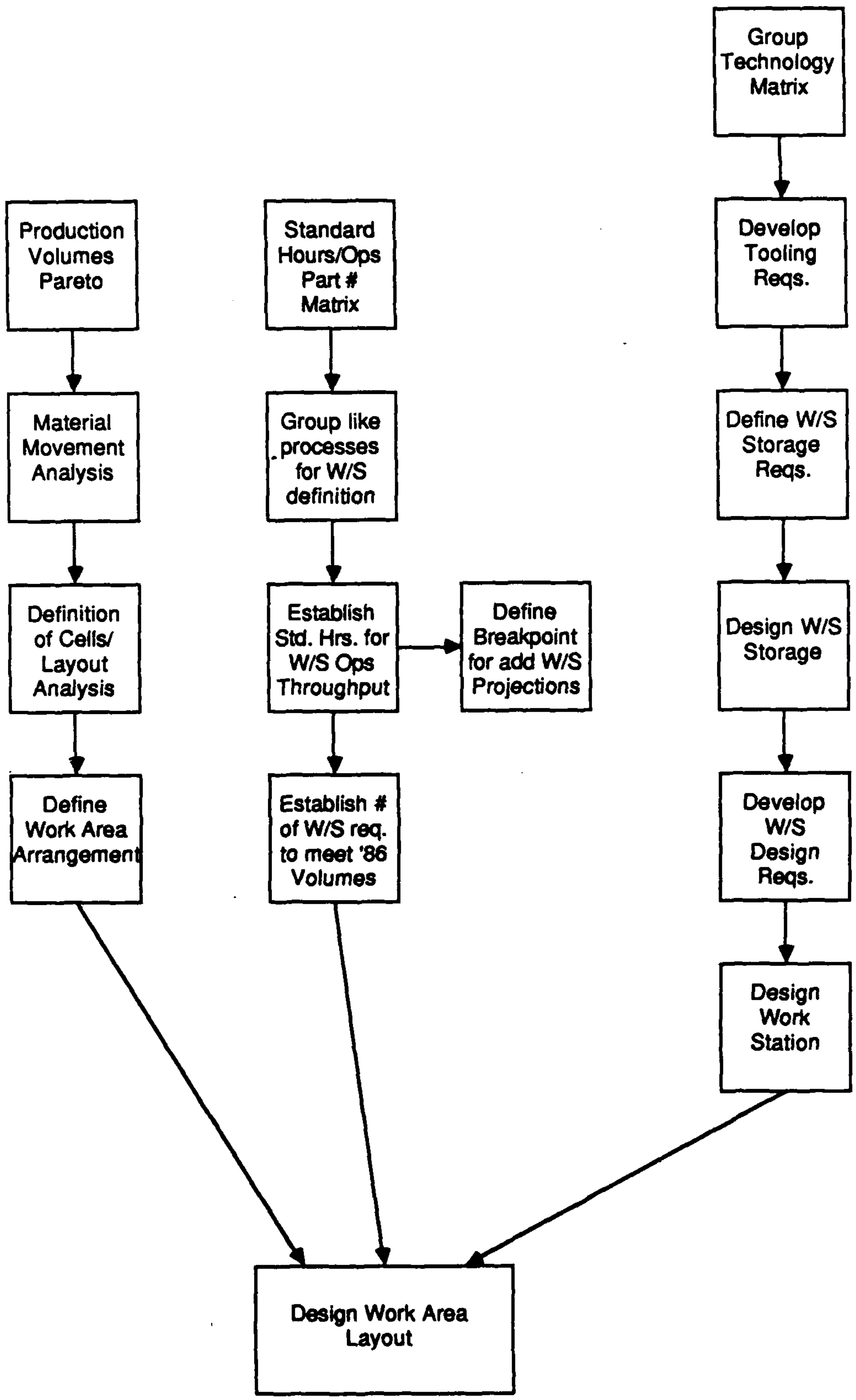


Figure 3.1.2-2 Development of Work Area Layout

variables can be defined as global considerations for developing cost drivers for the overall project. The criteria then provide the specific elements which must be evaluated for specific ROI and payback analysis that will determine the justifiability of each of the improvements recommended.

3.2.1 Definition of Hierarchical Manufacturing Levels

The current trends in analyzing manufacturing operations structures is to view the manufacturing structure in a hierarchical manner. This approach provides the basis for determining the ways in which manufacturing is performed as well as the influence of the structure on the actual manufacturing operations.

The primary divisions that are typically defined are:

- Company
- Division
- Factory
- Work Center
- Work Cell
- Workstation/Process

Each of the hierarchical levels below the Division level is described in detail in the following paragraphs. While some of these descriptions may imply computer controlled actions at each level, these actions are actually possible either through a computer control system or through a manual "paper-based" system. Subsequent sections (Sections 4 and 5) define each of the hierarchical levels as they apply to the current FM & TS operations and the proposed FM & TS manufacturing operations respectively.

Factory

The factory level (also known as the plant level) is responsible for all production operations for a related set of products. In response to divisional or corporate forecasts, the factory develops a manufacturing resource plan to achieve these goals. In addition, the factory is responsible for monitoring the overall efficiency and productivity of the manufacturing resources.

Included within the factory are the shipping and receiving functions, warehousing, administration and manufacturing services, data processing, and the entities which are responsible for the production processes.

From a systems perspective, the factory level is where MRP (Material Requirements Planning) or MRP II (Manufacturing Resources Planning) systems reside. These types of systems take a macro view of the production operations as an integral part of the entire operation of the factory. Production and the processes entailed are viewed from this level as financial entities and therefore, the most important information required at this level is the rate of

production, inventory levels, production completions, and other financial related data.

Work Center

The work center level (which is shown conceptually in Figure 3.2.1-1) is responsible for the production of a specific product line or a set of related subassemblies or products. In a general view, the work center is responsible for coordinating the actual manufacture of a product involving all of the required processes and procedures.

To meet production objectives, the work center is responsible for a greater range of tracking production than a units/time period level. The work center allocates specific resources and provides near-term scheduling to meet the overall factory production plans. In performing this, it is responsible for authorizing the actual manufacture of products, the release of materials to the manufacturing floor, as well as the transference of product from manufacturing to shipping.

The work center is also responsible for monitoring the performance and near-term availability of work center resources. These resources include inventory levels and replenishment, material transfer and transportation means, processes, in-process storage, and several others.

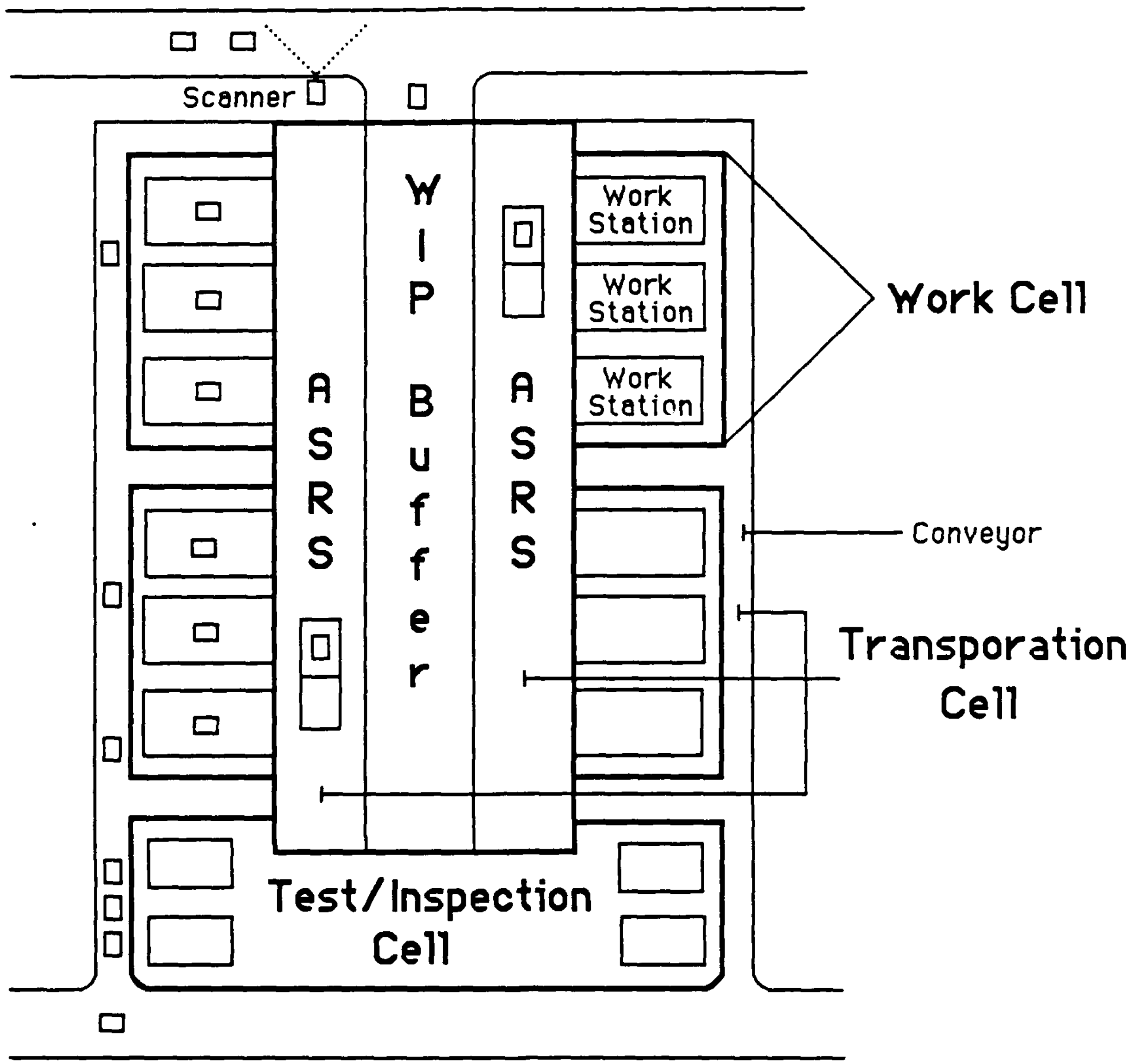
Work Cell

The work cell (whether physical or logical) is responsible for performing a specific set of related operations or factory services. This can be defined as a specific sub-assembly or a specific process required by all sub-assemblies or assemblies. The work cell is also responsible for coordinating all activities among the workstations within the cell. This includes authorization of workstation activation and deactivation, tool changes, intra-cell material handling, and other inter-station activities.

The work cell also monitors at a discrete level each of the workstations within the cell as far as exact location and current process being performed. With this data, the work cell can then direct corrective action with respect to exception conditions at workstations or can notify the local operator as to a required action.

Workstation

Workstations are responsible for controlling the execution of one or more linked processes. The workstation initiates commands for specific actions to the appropriate process. In addition, the workstation monitors process activities through command acknowledgements and exception alerts.



Responsible for production of a specific product line or set of related subassemblies

Optimizes near-term resource schedules to meet factory production plans (specific resource allocations)

Authorizes actual manufacture of products associated with the work center

Monitors performance and near-term availability of work center resources.

Figure 3.2.1-1 Work Center

Process

Processes are specific steps executed within an operation. At this low level, process controls provide acknowledgement of each command received and report each relevant action taken. As with workstations, the process control level reports exception conditions with respect to specific machine operations.

A conceptual overview of the workstation and process responsibilities is shown in Figure 3.2.1-2.

3.2.2 Production Characteristics

Production characteristics describe the type of production operations that are employed for a particular set of products and are dependent upon a variety of factors including build schedule, lot sizes, product characteristics, and many other factors. The primary division of production characteristics is between functionally oriented (or process oriented) manufacturing and product oriented manufacturing. Additionally, characteristics of production may define the need for a mix between a functional and product orientation.

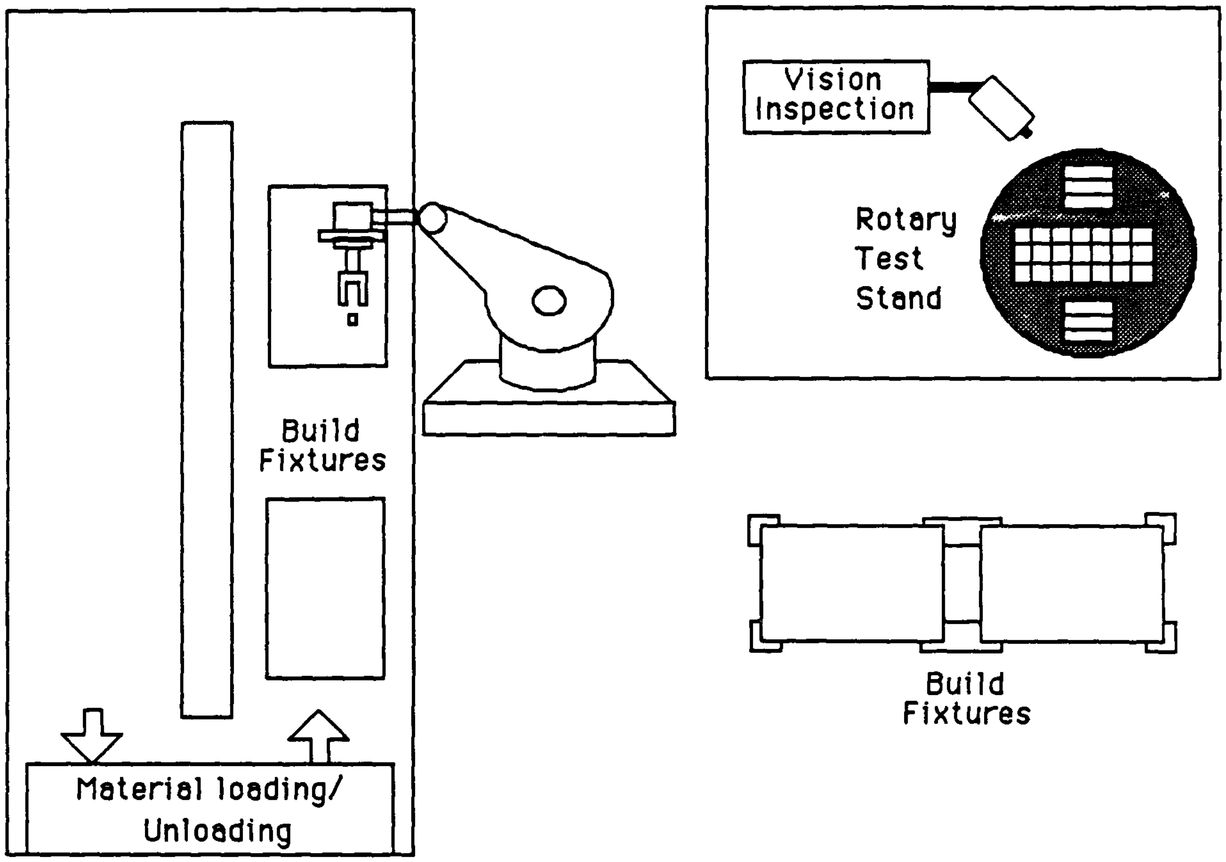
The assignment of production characteristics need not be global for an organization but should be determined when applied to each of the hierarchical levels within the factory. The following paragraphs briefly summarize the major distinctions between process and product manufacturing orientations and what the determining factors are in applying these characteristics at each manufacturing level.

Product Oriented Manufacturing

Product oriented manufacturing is characterized by grouping all functions common to an individual product in a close proximity or physical area. This means that each work area is strictly dedicated to the manufacture of individual products. In this regard, a major requirement of product oriented manufacturing is that there be sufficient capital equipment allocated to support each individual product line.

Process controls are characterized as those required specifically on a product by product basis, however production control is simplified by the single product focus. Inspection, under production oriented manufacturing, is again product oriented and is facilitated by a step-by-step process that follows the product through the production cycle. Training materials and aids must also be developed on a per product basis for each operation performed.

Material control is dedicated to each product and requires multi-point material distribution control for allocation of parts.



Workstation: Responsible for controlling execution of one or more linked processes
Directs commands for specific action to appropriate processes
Monitors process activity through command acknowledgements and exception alerts
Acknowledges work cell commands

Process: Responsible for executing specific steps within an operation
Provides acknowledgement of each command received and reports each relavent action taken
Reports exception conditions with respect to machine operation

Figure 3.2.1-2 Workstation/Process

Functional (Process) Oriented Manufacturing

In contrast to product oriented manufacturing, a functional orientation groups processes common to all products in a physical area. This can provide an advantage for products requiring that a high degree of repetitive tasks be performed for the manufacture of the product. In that regard, while operators do not require shifting from processes, a level of sameness in the work can decrease productivity.

One of the major benefits of functionally oriented manufacturing is that production resources (such as capital equipment) is centralized and requires less duplication. As part of this benefit, product flow is forced through a common location, allowing for more control and tracking of production processes. This concentration on the process allows development of universal process controls and the development of more generic work aids and training.

Material handling and control becomes more concentrated under this scenario as limited classes of material are established for each single point of use or work area. In contrast, production control must be more spread out to monitor more production points for an individual product.

Combined Functional/Product Orientation

The combined functional/product manufacturing orientation represents the most common organization of characteristics in most manufacturing environments. This mix allows processes that are common to all products to be grouped in separate, distinct physical areas. In turn, processes that are unique to a specific product can be isolated in a separate physical area for more efficient production control.

The functional/product mix provides defined integration points for product/process routing splits and merges. Material handling is optimized by the ability to define specific material class requirements for each of the work areas. In addition, resource utilization is optimized due to the fact that resource orientation is defined for the most productive work flow.

3.2.3 Definition of ITM Project 80 Objectives

ITM Project 80 has a defined objective to increase the efficiency of the Card Test/Device Test areas by the use of improved material handling systems. ITM Project 80 addresses the modernization of the factory layout of the printed circuit card test and final device assembly areas within the Flight Management and Targeting Systems (FM & TS) department. This modernization is to be accomplished through more efficient use of floor space, utilization of vertical storage and retrieval systems (VS/RS), consolidation of printed circuit card

testing, streamlining work flow, and installation of ergonomically designed work cell/work centers.

The primary concentration of efforts for performing ITM Project 80 are focused on the overall structure and layout of the card/device testing areas, workstation design improvements, and improved material handling means.

3.2.4 Definition of Variables and Criteria

The variables and criteria for Project 80 are used to define more discretely the areas that most benefit from material handling and production flow improvements. The variables represent the major aspects of production operations while the criteria define the ways in which improvements can be measured.

Manufacturing operations variables are those areas within a manufacturing operation that are changed or affected by changes within the operations to optimize production. These variables are defined by three major categories:

- Production
- Material
- Information

Production Variables

Structure. The structure of production can be defined either in respect to the hierarchical levels defined earlier or as a specific operation's organizational structure. Organizational structures can greatly affect the flow of production, especially in the structure's responsiveness to the manufacturing flow problems and in its facility to implement modifications and changes to the manufacturing processes.

Layout. There are a number of ways a production area can be physically organized on the shop floor and this physical layout can greatly affect the manufacturing production flow. While this area is described in greater detail in the following section, it should be noted that there are a number of ways that a manufacturing area can be laid out but the specific layout depends upon the goals for the area and the criteria defined for that area.

Process Flow. In conjunction with layout, process flow can be optimized to group resources in a specific area and to consolidate material handling efforts. The definition of an optimized process flow is a major factor in defining an optimum physical layout.

Group Technology. Group technology addresses two major operational philosophies, one concerned more with the cellular organization of processes

and work areas, and the other focusing on specific products and product families. These concepts are explored in detail in Section 3.3.

Material Variables

Material Management. The effective control and management of materials is key to efficient and profitable manufacturing. Material management encompasses scheduling materials (both raw materials and work-in-process) as well as being able to monitor material usage and production completions.

Material Handling. Material Handling ranges from totally manual to fully automated and the selection of the appropriate material handling methods depends upon the definition of the appropriate criteria such as product characteristics and movement distances required.

Information Variables

Systems. Information systems can, like material handling methods, range from totally manual to fully automated. All manufacturing processes at any level include production information systems and it is important to define systems that are responsive to the manufacture of a product and that aid in that production rather than affect it adversely.

Control Networks. These networks, either formal or informal, serve to monitor and control production processes more accurately, thereby allowing other operations to be targeted for improvements. With the advent of computer controlled networks, much of the lower level control functions can now be readily automated dependent upon the specific criteria for a process.

Production Criteria

Production criteria are necessary for the development of any facility/operations improvement program. These criteria cover a wide range and an all inclusive list would be far too long for consideration in any project. The following paragraphs describe some of the major production criteria that have been used in the development of improvements for the FM & TS Tech Mod programs.

Capital Investment (Duplication of Equipment)

Capital equipment should be considered for duplication when product volume processed requires time in excess of 96 hours/week (greater than 2 shifts per 24 hours) or the unit is critical to production such that down time in excess of one shift would seriously impact production.

Square Footage Required (Process vs. Product)

Consideration must be made for flow lines and/or product queues. If the area occupied by a single product-related process exceeds 50% of the space utilized, the process should be incorporated into the product flow. This allows processes to function at peak efficiency and product specific operations to be performed in an optimum area.

Process Time for Separate Operations

If process time at a remote location (including movement) exceeds one shift, that process should be incorporated into the product flow. Alternatively, a facility relayout may be considered to bring separate operations together. (Obviously, the cost effectiveness of process incorporation or facility relayout is governed by product volume, available capital, and facility costs.)

Product Profile

The following factors dictate product oriented assembly (versus process oriented) to avoid quality/damage problems:

- *Product Size.* Weight or volume of product precludes movement to a remote processing point without risk of damage.
- *Process Complexity.* Process employed has an intricate or extensive set of steps necessary to accomplish a particular task making it inconvenient or subject to error if intermixed with other processes.
- *Parts Count.* Unit has high number of unique parts which, by organizing in a single product workstation, ensure higher quality and throughput when contrasted with a multi-product workstation.
- *Special Handling Requirements.* Unit configuration or delicate nature dictates minimizing handling or transport during intermediate assembly steps.

Material Transport Related Factors

If time taken for

- Material Movement (distance)
- Queueing time (Wait States)

exceeds 20% of the actual processing time, an operation should be considered for product line orientation.

Personnel (Skill Level, Training, Productivity)

Ability to specialize in one product-related process area should be weighed against impact on quality/training of combining similar operations to concentrate equipment or processes.

Equipment Utilization

Process should utilize equipment to the extent that simple payback can be achieved in 1 to 2 years. Actual operational time may dictate decision to implement shared usage if significantly below 50%.

Ease of Implementation

Includes training and development of assembly, test aids, and software.

Level of Support Services Required [Heating, Ventilation, Air Conditioning (HVAC)]

Cost factor for consideration when expanding or relocating uses additional support services.

Product/Process Flow Optimization

Factors which impact idealized (or linear) area flows must be defined. Acceptable percentage deviation must be established between idealized and actual by modeling product and process arrangements.

Ease of Expansion/Capacity

Initial investment factor should allow a minimum of 20-50% increase in flow (single shift). Expandability should be evaluated on payback of process time efficiencies similar to justification for base unit (1 to 2 years).

Throughput

Optimized combination of operations minimizing set-up and tear-down times so that equipment utilization is maximized for productive output.

Equipment Limitations

Factored in terms of:

- Percentage of area occupied
- Percent of total utilities consumed
- Percent of increase in labor expense

to overcome capacity limitations.

Changeover Capability (product-to-process and vice versa)

Key factor employed in major factory realignments. Normally encountered in multi-step equipment employing universal tooling or fixtures.

Viability

Must have rational basis for justification in terms of real savings in:

- People
- Materials
- Time

Batch vs. Unit Build

Primary factor is impact of set-up and typical duration of key elements like diagnostic time, tool change-out, etc.

Number of Products/Options Manufactured

Line orientation will optimize mix of products and calculated percentage of options (either projected or historic).

Volume Impact

Quantities exceeding 25% of total work at an operation should be considered for separate area based on accumulated weight of other factors. Above one-third, volume should be the determining factor.

Trade Off Analysis

The criteria described above must be valued as it applies to each of the specific production variables. This requires selecting the most significant criteria (as shown in Figure 3.2.4-1) and developing a means of quantifying its effect on the production variables.

Once the variables and their effect on production have been defined and criteria for each of these variables has been weighted for relative importance, it is possible to develop a logical model that will aid in the cost trade off decision making process.

3.3 Work Area Design

In developing improved work area designs, the project team employed a specific methodology that utilizes a great deal of production and product specific data to aid in the development of an optimum work area. General systematic layout planning methods were used in conjunction with methods developed specifically for ITM Project 80. The specific methods employed for ITM Project 80 are described in Figure 3.3-1. In general, these can be characterized in four phases:

1) Location
2) General overall layout
3) Detailed layout planning
4) Installation

In addition to these four phases, five major considerations are used for systematic layout planning. Mnemonically, these are referred to by the letters PQRST. These are defined as:

P= Product plus variations and characteristics
Q= Quantity or volume
R= Routing or process (this involves both sequence and machinery utilized)
S= Services and support
T= Timing of PQRS (when, how long, how soon, how often)

These primary considerations are employed in all phases of the work area design.

As shown in Figure 3.3-2, three primary sets of data (Production Layouts, Production Flow Studies, and Process Matrices) are used to define each work area's specific requirements along with providing some of the raw data used to analyze the applicability of Group Technology. These factors are then used to develop workstation requirement profiles which in turn lead to the development of workstation designs. The final workstations are then grouped (either functionally or by product) to develop optimized work cells.

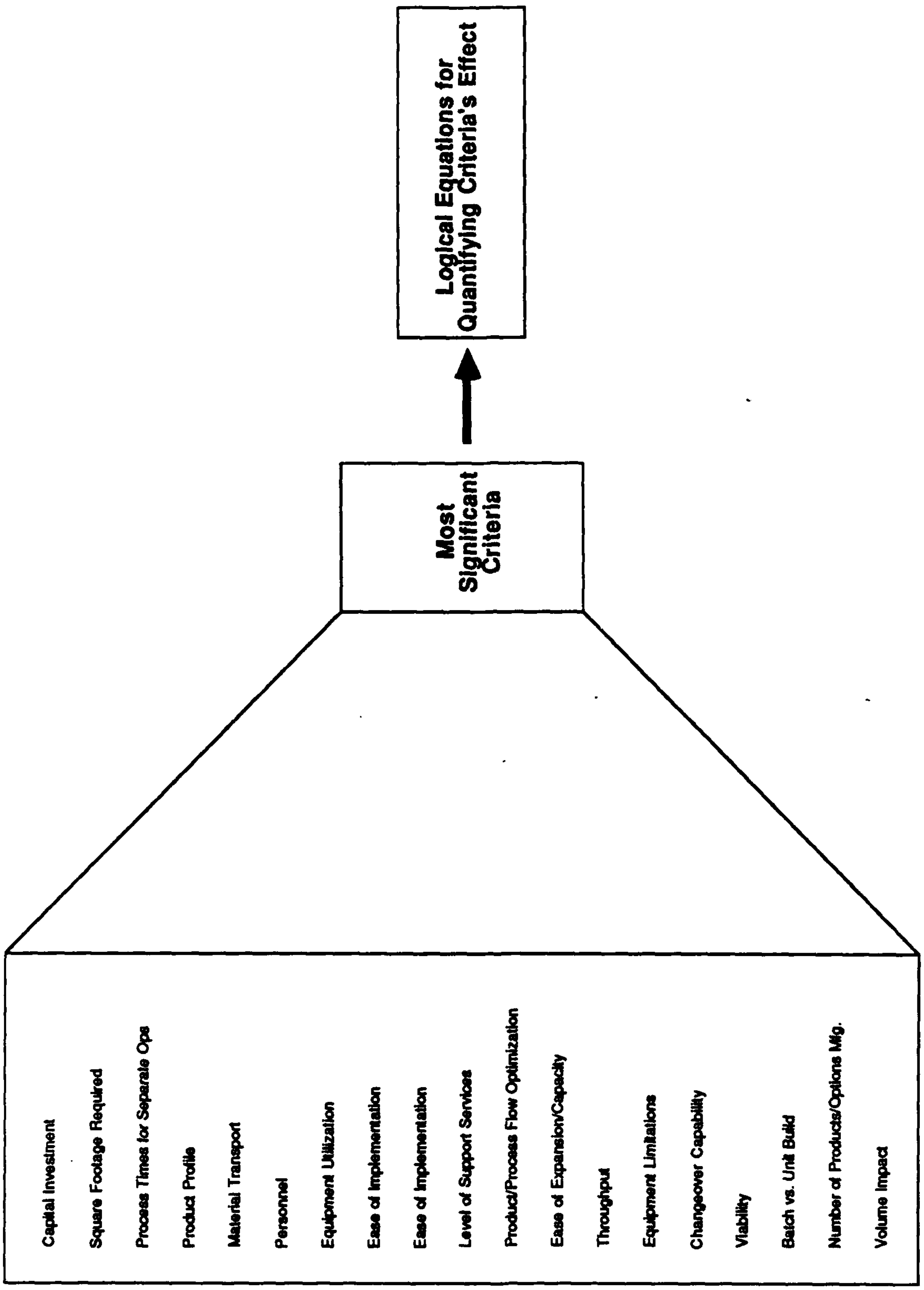


Figure 3.2.4-1 Valuation of Criteria

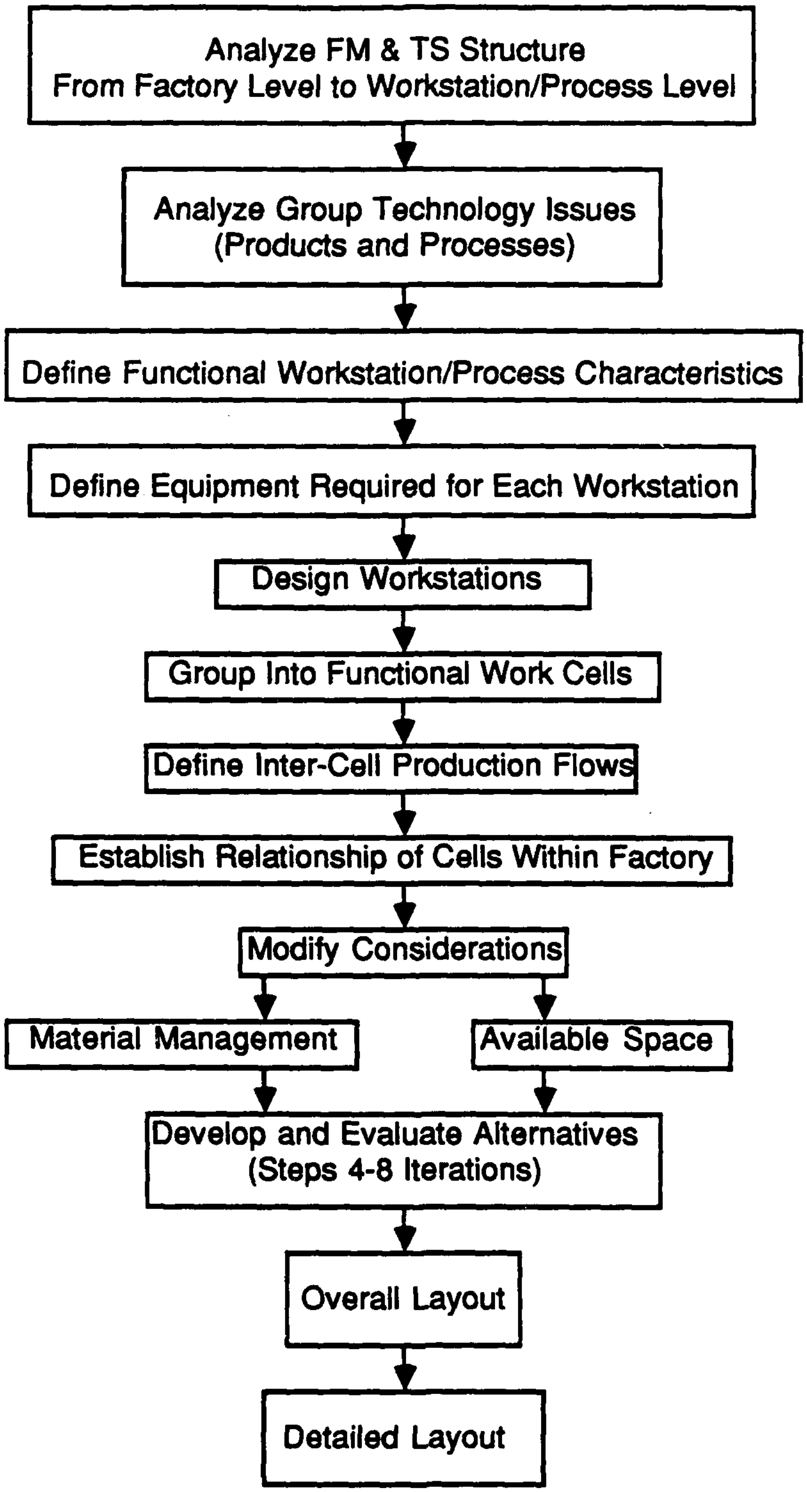


Figure 3.3-1 Methodology Flow Diagram

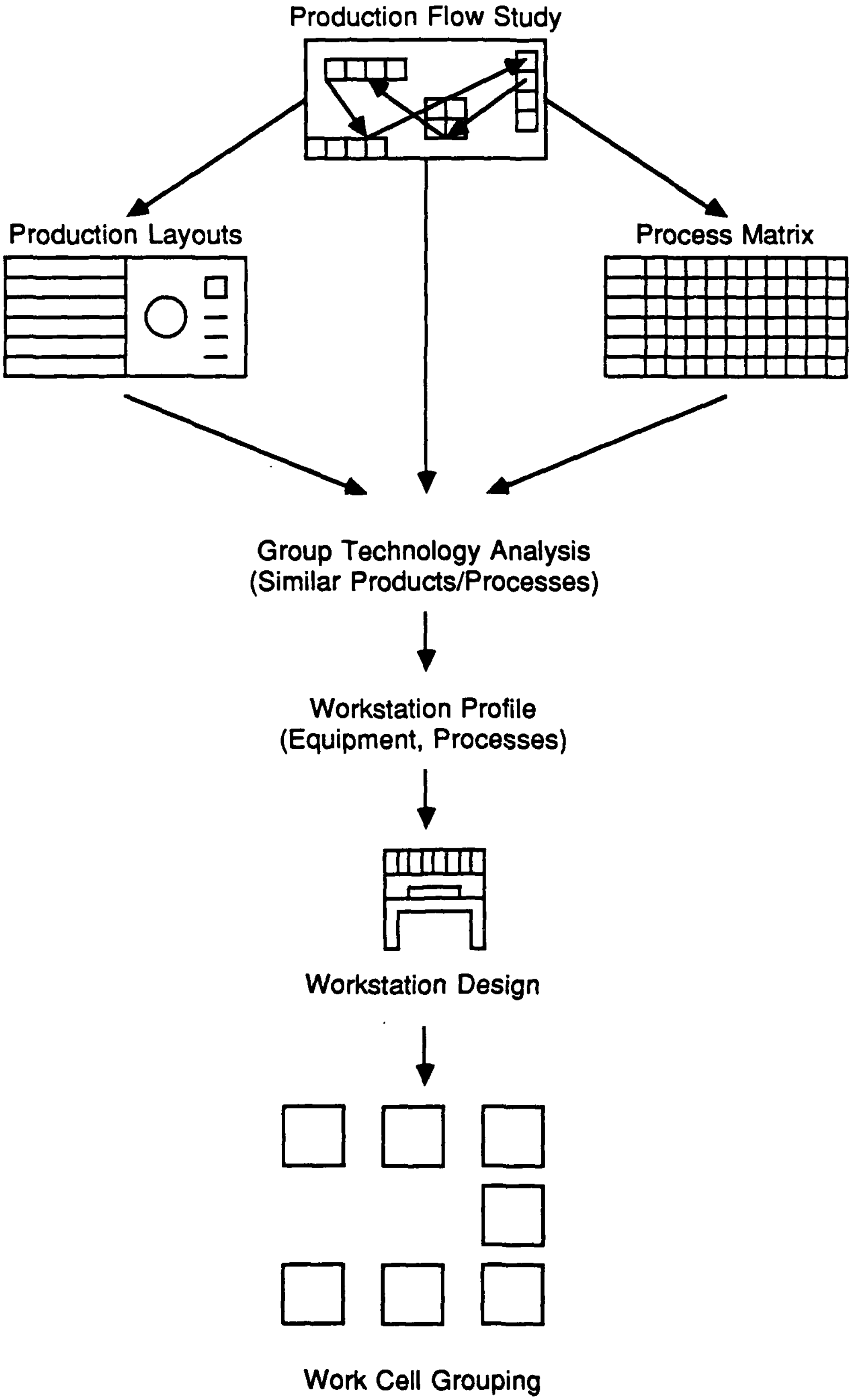


Figure 3.3-2 Work Area Design Methodology

The different variables and criteria are employed during this process at the workstation and work cell level to ensure that the designs meet the overall requirements set forth by ITM Project 80. The following section provides an overview of the components employed by this methodology and how the results are developed.

A production flow study was performed by Honeywell's Tech Mod Industrial Engineering Group to document the locations where the operations called out on the production layout are actually performed in the "As-Is" operations. This provides input into determining the groupings of operations at specific workstations and work cells.

Production layouts represent some of the most important input of data to the design of work areas. Production layouts not only provide routings of the various products produced but several other important pieces of information. These include:

- Operations callout numbers and descriptions. These provide a shorthand method for analyzing how the operations fit within the routings.

- Production process details. These provide specific process details for the more complex operations called out by the layout summary. Included are references to commonly used processes detailed in supporting documents. This is key to defining the operations performed at a specific workstation.

- Operation standard hours. These provide a relative method of measuring the time required to perform the called out operations.

- Parts and materials. Required subassemblies, parts, and materials (paint, ink, wire, coatings, etc.) are listed in the layout at the specific step where required.

A process matrix was then developed to determine the hours required annually for each operation. The following methodology was employed to develop the process matrix:

1) Production layouts provide initial data for establishing standard hours per operation per part number. Data was correlated with operation descriptions along x axis, part number along y axis, and standard hours entered in matrix grid.

2) Production totals (box counts) were entered for years 1986 and 1987 on separate matrices. These were then multiplied for each part number and each new operation column was totaled (total hours per discrete operation) per program.

3) Production layouts were referred to subsequently for grouping operations that were (or could be) performed at a specific type of workstation. These were reviewed by the appropriate production personnel for accuracy. The matrix was then consolidated into major categories for both 1986 and 1987 production. This was then verified for 1986 using the Foreman's Cost Report (for total hours in operational area).

4) Business volume projections were established for the operational area and standard hours were projected for ten years using an established percentage growth for the FM & TS operations derived from FSO marketing projections.

5) Actual hours for each type of workstation were established using a cost variance ratio established by the FM & TS cost accounting department.

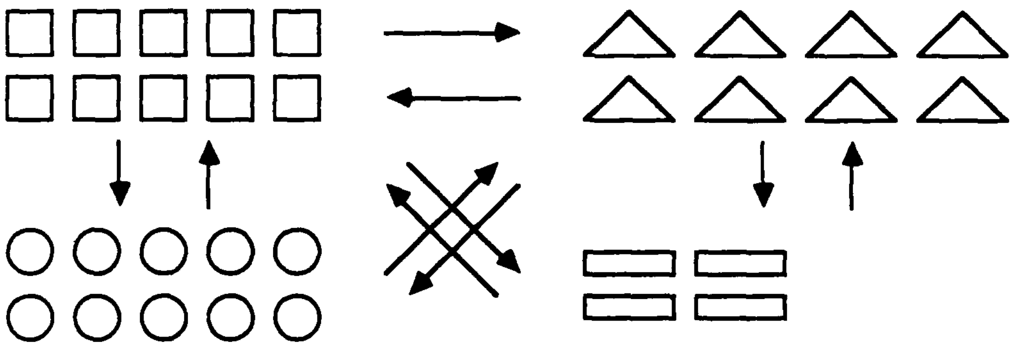
6) Actual number of workstations was established by dividing actual hours per type of workstation by 1800 hours. The assumption of 1800 hours/year/employee allows for 80 hours vacation, 80 hours holiday, and 120 hours for lost time (sick, jury, etc.) from the gross 2080 hours (52 x 40 hours) available each year.

Each operational area was analyzed utilizing this type of matrix to accurately determine the number of workstations and as input in developing their location within the overall area.

The workstation profiles defined during the development of the operations matrix were then analyzed for processes performed at each type of workstation. These processes then determined the equipment requirements for each workstation. A generic workstation is then defined which can meet the overall requirements of all of the possible stations for the work area. The specific equipment requirements for each station and the generic workstation design is then employed to define the configuration of each of the specific workstations for the work area.

Once all of the workstations have been designed, the grouping of the stations is laid out based upon the process flow to provide optimized routings for the majority (approximately 80%) of the product that will be built in the work area. In addition, the accessibility of resources is analyzed in relation to the work cell designs as well as the physical characteristics of the products assembled. Examples of cellular groupings are shown in Figure 3.3-3.

After the work cells have been developed, they are laid out for optimum routing between the cells. Once the work area has been designed, the material handling and storage requirements are developed to facilitate the process flow between cells.



Clustered, jumbled:
- Clusters of generic workstations
- No attempt to organize by product flows
- No easily identifiable flow path or, organization contrary to flow path

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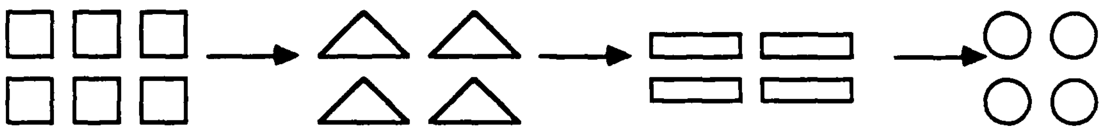
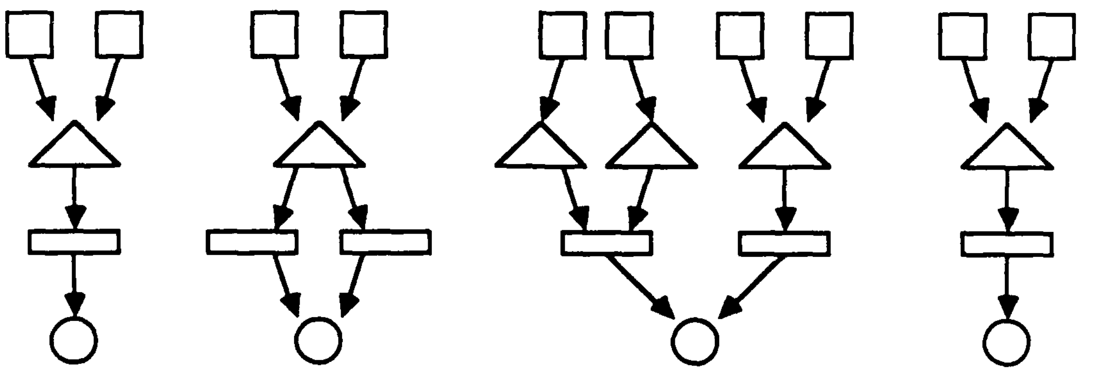


Clustered, flow line:
- Clusters of generic workstations
- Organization by product flow



Cellular:
- Unlike workstations grouped into cell to produce a product family
- Only one wrokstation of a type, except where more needed for balance
- Cell-to-cell organization by product flow

Figure 3.3-3 Work Area (Cell/Station) Organization

3.4 Equipment Selection Approach

The selection of equipment employed for ITM Project 80 was defined using a general approach and then a more refined methodology based on this approach was used for each specific piece of equipment. This general approach is described below and presented pictorially in Figure 3.4-1.

The first step in the selection of equipment is to define all of the possible equipment required to perform the process necessary for production. This was approached from several different vantage points:

- Current equipment survey. All equipment currently used in a production area was reviewed for functionality, age, ease of repair and availability of spares, as well as several other factors specific to the unique piece of equipment.

- Production processes. The processes called out by the production layouts were reviewed to determine if current equipment could adequately perform those processes and what new available equipment could be used to perform production processes.

- Technology overview. Recent technological advances in production equipment were reviewed to ensure that during the equipment evaluation process that all applicable or substitutable technologies were understood in relation to the production area and the processes performed there.

Following the establishment of production equipment requirements, selection criteria were established to evaluate each individual piece of equipment. A general overview of these criteria includes:

Physical Criteria

Conformance to Requirements - Equipment meets (or exceeds) capabilities required, such as capacity, frequency, accuracy, MTBF.

Ease of Use - Required level of technical expertise/training necessary to effectively operate equipment.

Technology Level - Employment of state-of-the-art features or innovative application of technology that enables user to more effectively perform intended task.

Multiple Users - Ability to support more than one user simultaneously (either operating or programming).

Network Capability - Ability of equipment to be networked to other similar units or to centralized data files or controller.

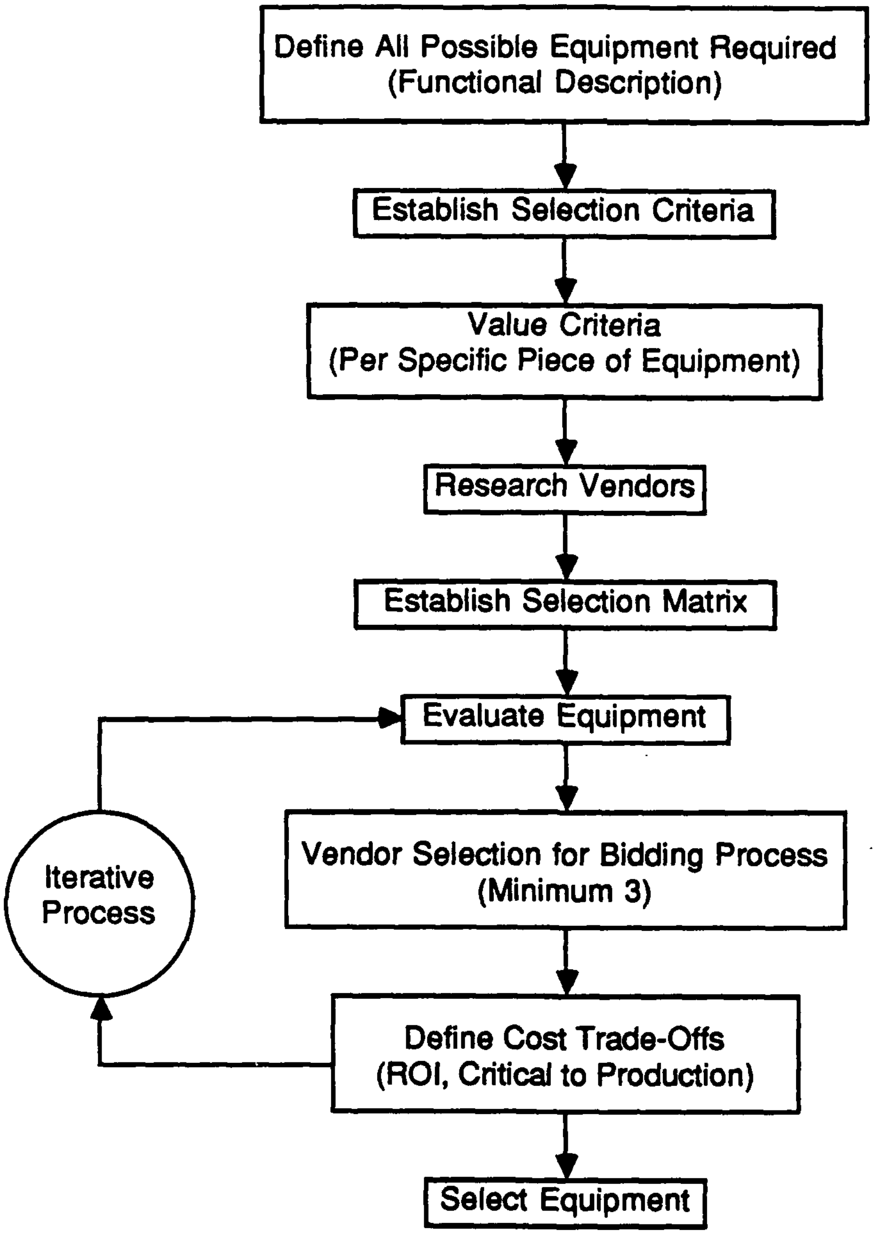


Figure 3.4-1 Equipment Selection Approach

Defect Detection and Reporting Capabilities - Effectiveness of reporting of defects on unit under test so as to permit repair in shortest possible time.

Support

Serviceability - Ease of maintaining equipment plus vendor's support capabilities/response level.

Technical Support Requirements - Level of technical expertise/training required to effectively support (program, maintain, etc.) equipment.

Cost of Programming - Relative effort required to develop operational programs for equipment.

Physical Characteristics

Portability/Moveability - Effect on critical adjustments/required participation of vendor.

Ease of Installation - Effects on installation due to physical size, mounting/isolation requirements, vendor or customer team required.

Ease of Upgrading/Modifications - Convenience of installing additional capabilities/features/options as well as field changes (both hardware and software).

Physical Interfacing - Relative level of ease in providing interface to unit under test (UUT) or other equipment being operated on.

Cooling Requirements - Special HVAC requirements necessary for equipment due to operating temperature and range.

Environmental Impact - Provisions required due to equipment-generated heat, noise, vibration, etc.

Power Requirements - Exceptional or unusual power requirements of the equipment as compared to similar types of equipment being considered.

Special Environmental Requirements - Special environment requirements such as "clean" room, dark room, isolation mounting, etc.

Vendor Evaluation

Delivery - Availability of equipment in accordance to needs.

Vendor Reliability - Supplier's record in delivering and supporting equipment (evaluate by questioning other users).

Equipment Cost - Evaluated in relation to other similar pieces of equipment under evaluation for a given use (i.e., relative cost of unit).

It is then necessary (for each piece of equipment required) to "weigh" or value the criteria, selecting the most important criteria for a specific piece of equipment. The weighted factors associated with that equipment are then used to perform an initial vendor review.

The weighted criteria is ranked for level of importance or applicability to the decision making process and listed on one side of an equipment selection matrix (shown in Figure 3.4-2). This matrix is used to evaluate the vendor's product's applicability and to screen out the vendor's whose equipment is not suitably matched to the requirements.

The vendors whose products meet the initial requirements are sent specifications (RFQ's) to respond to. Once the initial cost of the equipment is established, the selection process then becomes an iterative process of defining the cost trade-offs involved, determining if the ROI is sufficient and reviewing the criticality of the new equipment and its effect on production. The final step in this process is the purchase of the equipment and the initiation of the program's implementation.

Equipment Selection Criteria	Vendor A	Vendor B	Vendor N
Conformance to Requirements			
Ease of Use			
Technology Level			
Multiple Users			
Network Capability			
Defect Detection and Reporting Capabilities			
Serviceability			
Technical Support Requirements			
Cost of Programming			
Portability/ Movability			

Figure 3.4-2 Tooling and Equipment Evaluation Matrix

Equipment Selection Criteria	Vendor A	Vendor B	Vendor N
Ease of Installation			
Ease of Upgrading/ Modifications			
Physical Interfacing			
Cooling Requirements			
Environmental Impact			
Power Requirements (Normal vs. Exceptional)			
Special Environmental Requirements			
Delivery			
Vendor Reliability			
Equipment Cost			

Figure 3.4-2 Tooling and Equipment Evaluation Matrix (cont.)

SECTION 4

"AS-IS" PROCESS

The following section presents a description of the "As-Is" condition of the FM & TS operations. This includes a brief description of the type of product currently in production, the operations structure, the organizational structure as well as the personnel involved in FM & TS Production. In addition, the floor plans of the FM & TS Card and Device Test areas are included as well as the process flows for typical products. Also included is a characterization of the material flow and information flow as well as a description of the equipment currently used and an evaluation of its suitability.

An overview of the current "As-Is" process required to produce FM & TS products is depicted in Figure 4.0-1.

4.1 FM & TS Production Overview

FM & TS Production manufactures flight control products for major programs as well as producing spares for these programs.

4.2 FM & TS Program Profiles

Flight Management and Targeting Systems Production assembles and tests high technology military flight control and targeting systems built under specific customer contracts. Therefore, while there may be several products within a particular program, each program must be managed and controlled to comply with a specific customer's requirements. The systems that are built under each of the program's currently under contract to FM & TS are typically made up of a variety of components, including:

- Computers
- Control Panels
- Sensors
- Control Sticks
- Electronics Units
- Helmet mounted sight/sensor units

The orders for any one of these program's products may be made for complete systems, modification packages, or spares.

In addition to the various programs which are in current production, a significant amount of FM & TS Production's business is made up of military spares and/or repairs on older programs.

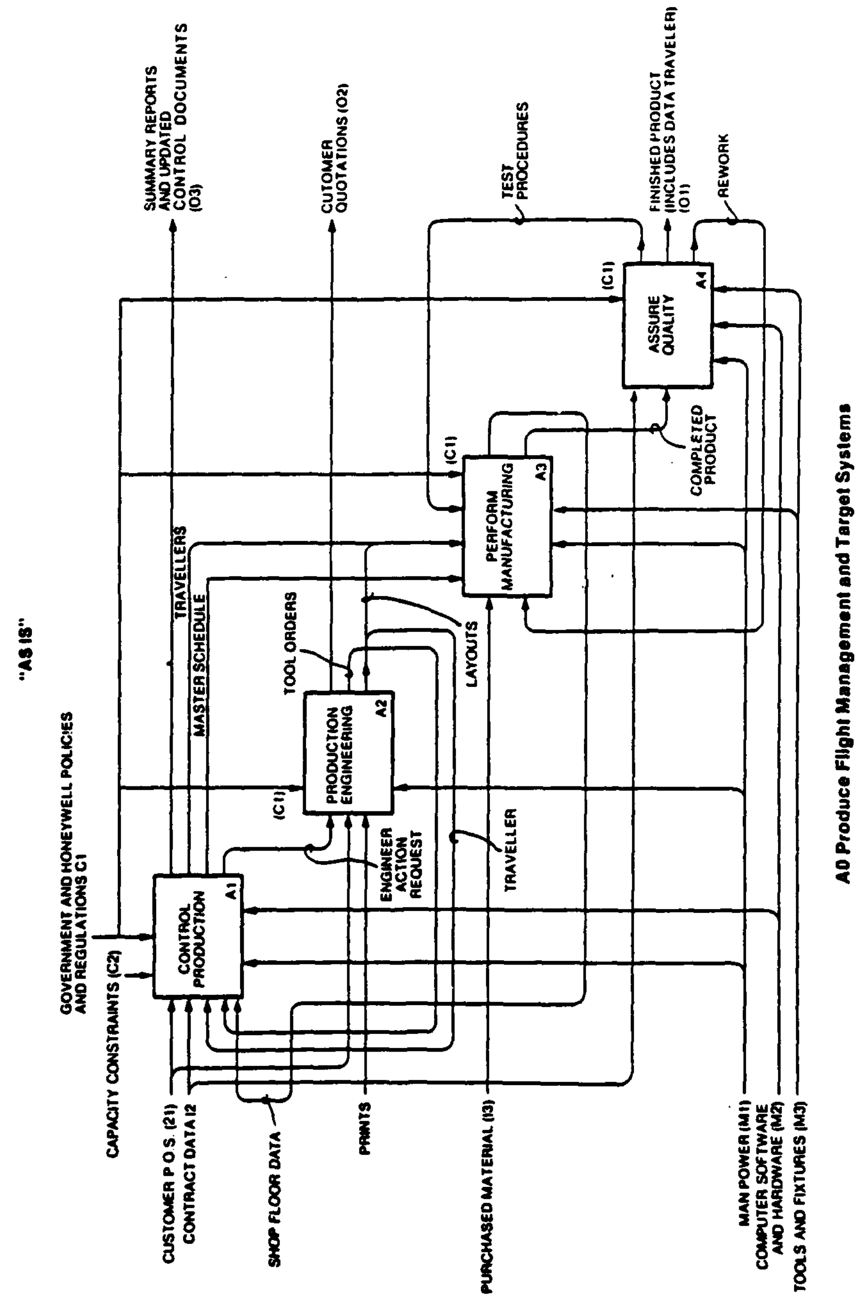


Figure 4.0-1 "As-Is" Production Process (FM&TS)

4.3 FM & TS Operations Structure

The following section describes the structure of FM & TS Production operations as well as the characteristics of the two areas primarily addressed by ITM Project 80.

The FM & TS Production operations structure is most appropriately described in terms of product orientation or process orientation or a mix of both at each of the hierarchical manufacturing levels described in Section 3 of this document. Briefly, the differences between product and process oriented manufacturing can be characterized as follows.

Product Oriented Work Areas:

- Allows all functions related to a product to be contained in a single organization
- Requires all equipment necessary to support a product to be controlled by that product group
- Provides all necessary support functions (e.g., material handling, production planning, QA, etc.) internally
- Concentrates all activities related to product operations within close physical proximity, thereby reducing material movement
- Requires dedicated personnel to perform operational (assembly/test) tasks
- Theoretically allows compact layout but this is dependent upon the size and nature of the process equipment and the product handled
- Minimizes material queueing by layout constraints
- Dedicates material handling to a product

Functional (Process) Oriented Work Area

- Concentrates assembly machinery and test equipment for shared usage (maximum utilization)
- Allows concentration of specific skills and development of technology centers
- Increases need for material movement from function to function

- Requires coordinated work planning function between process centers

- Provides support activities, generally, by outside "centralized" organizations

- Requires additional "aisle" space. Layout/space utilization is generally efficient from a process/material flow perspective.

- Allows material queues to provide for increased transits to using areas and combined throughput rates

The definition of these two orientations provide a basis from which to analyze the "As-Is" structure of the FM & TS operations. The hierarchical levels referred to in this section are more completely described in Section 3 of this document and can be briefly summarized as:

- Factory (which is represented as the overall FM & TS Production operations)
- Work Center
- Work Cell
- Workstation/Process

Work Centers

At the work center level (as shown in Figure 4.3-1), the division between work centers reflects both a product and process mix. The primary emphasis is on process for all of the major mature programs currently under contract and on a product orientation for all of the new or variable programs. The two work centers that are of concern for ITM Project 80 are the Flight Management Card and Device Test (card/device) work center and the Targeting Systems (targeting) work center.

The card/device work center is, in essence, a process oriented work center. The primary activities in the card/device work center are the test and calibration of circuit card assemblies (CCA) and the test, calibration, and environmental exercise of devices (black boxes) for the various programs.

The major characteristics of the card/device work center are the grouping of all process related functions, necessary equipment and personnel, and support functions in a single organization. While it is logical that this work center should be located in a geographically central area, this is not the case in the "As-Is" condition.

The targeting work center represents, on the other hand, a single product work center consisting of a number of unique processes. The targeting work center is a low volume, high quality work center dedicated to the production of advanced targeting systems produced by Honeywell.

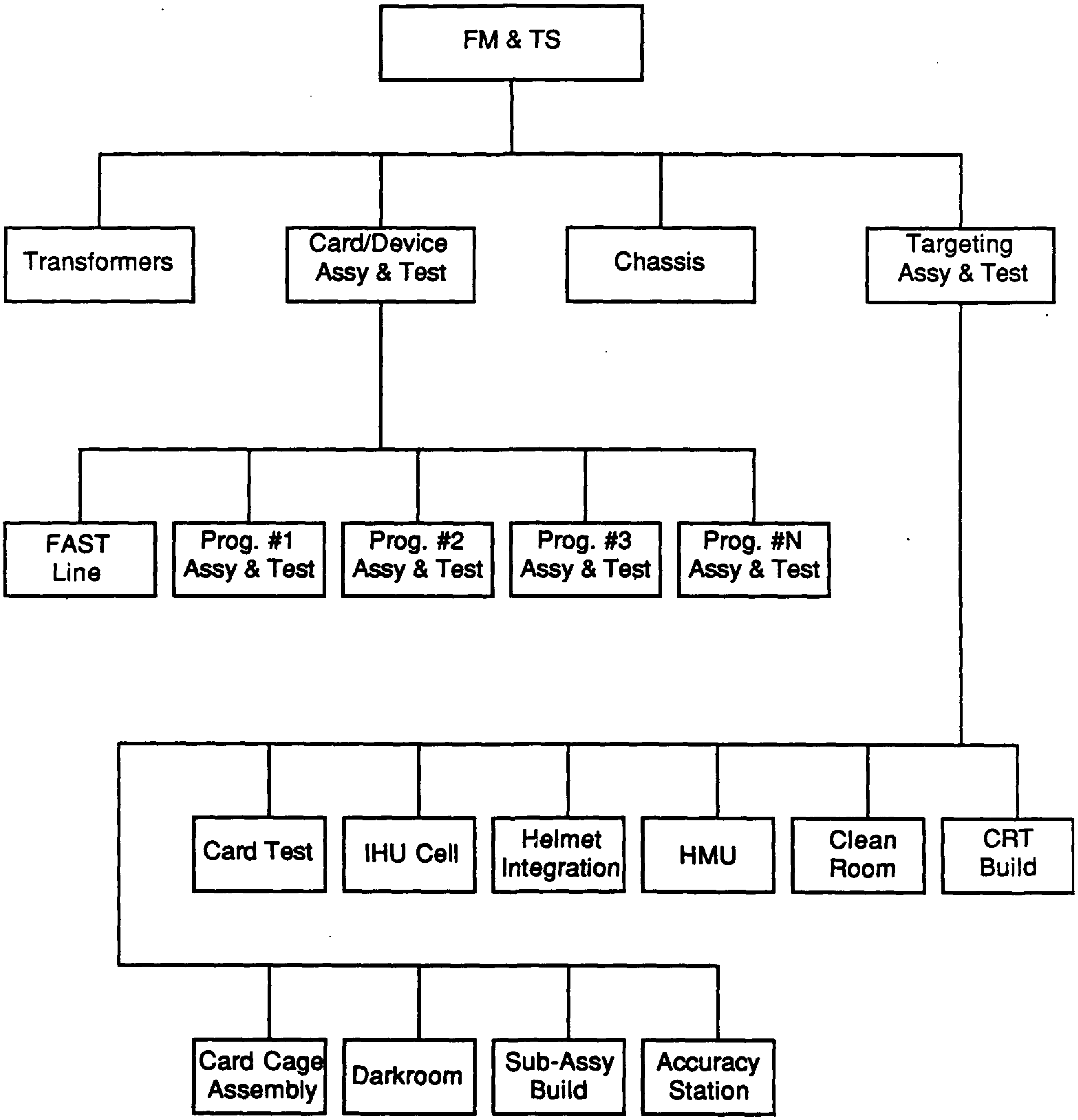


Figure 4.3-1 FM & TS Work Center Structures

The structure of the targeting area work center allows for a concentration of skills and the development of technology centers. Other functions are more centralized and coordination is required in controlling the work of this process center with other dependent centers.

Work Cells

The work cells within the card/device work center are primarily divided by product (or program) while the targeting work cells are primarily dedicated to processes. In the card/device work center, this is due to the fact that while this work center is process oriented, all of the items produced within it are unique to individual programs. This results in five work cells divided primarily along program lines.

The activities of these work cells are augmented by a special assembly work cell known as the Final Assembly Support Team (FAST) which includes assembly, modification, engineering order (E.O.) incorporation, and rework capabilities.

The work cells within the targeting work center are strictly dedicated to processes involved with the manufacture of the Integrated Helmet and Display Sighting System. These work cells are:

- CRT Build
- Clean Room Operations [Boresight Reticle Unit (BRU) and Sensor Surveyor Unit (SSU)]
- Helmet Display Unit (HDU) Build
- Helmet Integration
- Integrated Helmet Unit (IHU) Cell
- Card Testing Cell
- Card Cage Assembly
- Darkroom
- Sub-Assembly Build
- Accuracy Station

Most of the work cells that are contained within the card/device and targeting work centers can be characterized as combining all like functions in a designated location providing work space efficiency. These product and process cells also allow a greater focus on operator specialization as well as on process/quality evaluation of several different products.

Workstations

The workstations in the targeting area are primarily process oriented. This is typically characterized as one process per station. Additionally, in the card/device area, workstations are reserved for particular assemblies or models. While in the card/device area, the product orientation makes training somewhat more complex, the expertise of the operators allows for more flexible shifting of personnel.

4.4 FM & TS Organizational Structure

The FM & TS Production operations play a central role in Honeywell's Military Avionics Division's (MAvD) Flight Systems Operations (FSO) organization. The organizational structure of FSO is divided into several major functional areas, including:

- Production
- Program(s) Management
- Engineering
- Product Assurance
- Procurement

The areas within FSO are structured as independent, function-oriented organizations that report to other areas on a "dotted line" basis. Within the Production area of FSO, the organizational structure is primarily high-level-product oriented. These high-level-product related areas are divided into:

- Flight Management and Targeting Systems Production
- Missile System Microwave Production
- Printed Wiring Assembly
- Aircraft System Microwave Production
- Advanced Systems
- Central Production Services

While the divisional distinctions within FSO are primarily high-level-product oriented, the products produced by each group are also significantly distinct from a manufacturing process perspective.

The Flight Management and Targeting Systems Production operations are functionally divided into several areas, including:

- Production Engineering
- Production Control
- Assembly

These areas, which are separated organizationally, are interrelated to work together in an overall manner to support each of the products

manufactured by the FM & TS operation. In that respect, each of these divisions provide input and receive assistance from the other two areas.

While the organizational division at this level is functional, the interdivision communication is defined by specific product programs. While this requires comprehensive management by each of the supervisors, it allows for direct information exchange where it is most beneficial (i.e., for each of the FM & TS programs).

Section 4.3 presented the structure of operations within FM & TS Production and the preceding paragraphs have provided a general overview of the role of FM & TS within Honeywell's MAvD. The following sections describe the personnel within FM & TS in general as well as specifically focusing on personnel within the card/device and targeting areas.

4.4.1 Personnel

Of the total number of personnel employed by FM & TS Production, approximately half of these personnel are dedicated to support services while the other half are assigned directly to production activities.

Of the number of personnel dedicated to production in the card/device area, approximately 27% are operators and 73% are technicians. In the targeting area 40% are operators and 60% are technicians.

4.4.2 Group Leaders

Group leaders are responsible for a wide variety of activities including issuing, ordering, and moving parts; assisting and training operators; maintaining production related data; and other miscellaneous activities. A study was performed by Honeywell's Industrial Engineering Department to evaluate the amount of time group leaders in the card/device and targeting areas spent performing various tasks related to their specific area operations. The methodology for this study is presented in Section 8 of this document.

In the card/device area, group leaders spend approximately 43% of their time in material related activities (see Figure 4.4.2-1). While the categories presented in the survey results are broad (issue parts, schedule inventory, order parts), they do not highlight the time associated with activities such as locating parts and tracking kits. It should be noted that approximately 26% of the group leader's time is dedicated specifically to moving parts. Additional inefficiencies are incurred due to the lack of consolidation of the card/device area's activities.

In the targeting area, group leaders spend approximately 25% of their time in material related activities (see Figure 4.4.2-2). Again, while these categories are broad, there are specific inefficiencies in this area that are hidden due to the restricted space in the area and other factors.

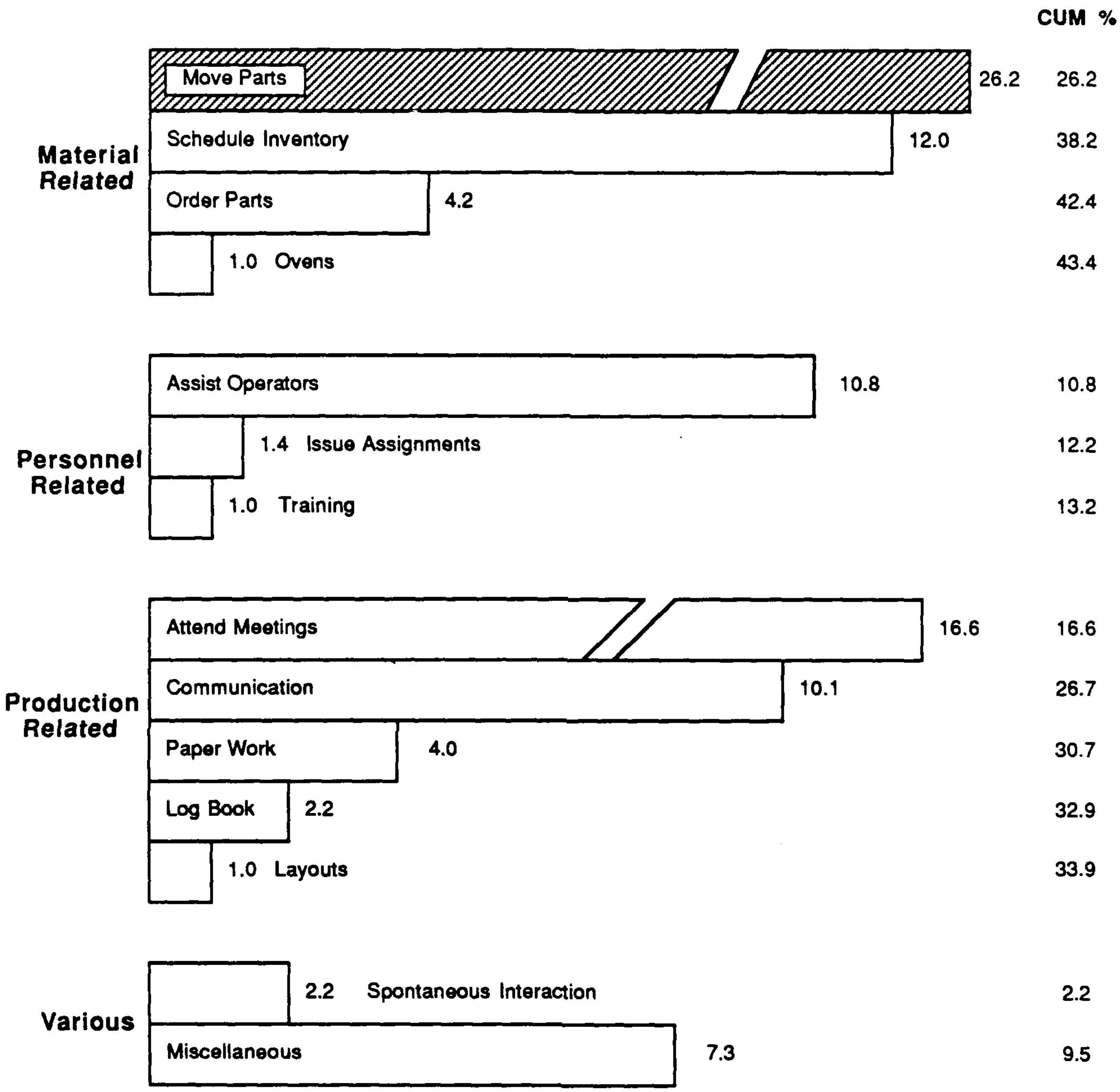


Figure 4.4.2-1 Card/Device Group Leader Collective Activities Ranking

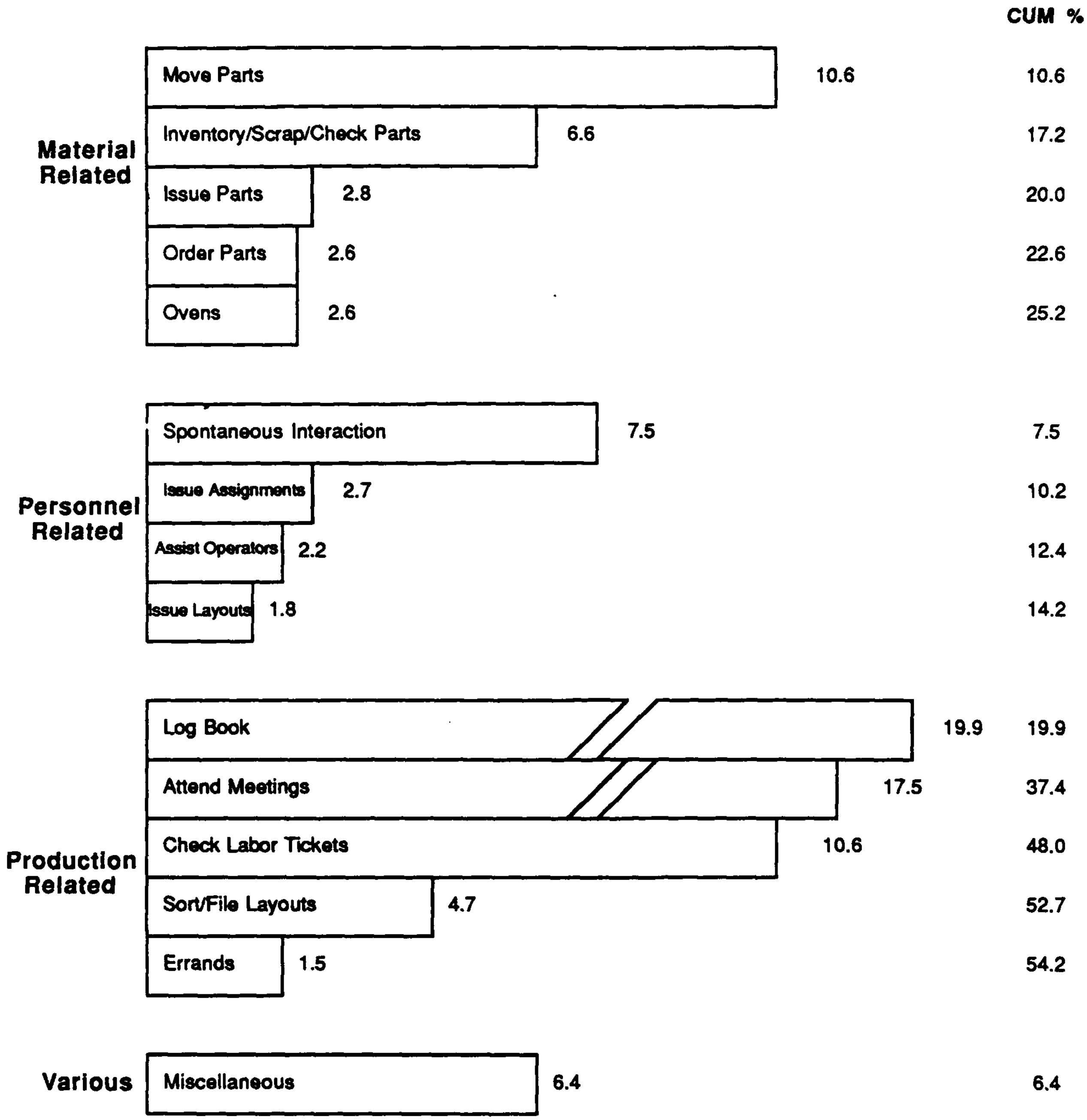


Figure 4.4.2-2 Targeting Group Leader Collective Activities Ranking

The survey also pointed out that on an average, group leaders did not work an eight hour day, but rather ten to twelve hour days. One of the goals of ITM Project 80 is to reduce the overtime expended by the group leaders which could be accomplished by reducing the material related activities to less than 10% of their overall efforts.

4.4.3 Production Control

Honeywell's Industrial Engineering department conducted a time sampling study among production control personnel supporting FM & TS activities. The results of this study are presented in Figures 4.4.3-1 and 4.4.3-2.

Out of total hours spent in support of production, the survey revealed that overall, an average of 30% of a production controller's time was devoted to materials related activities with a portion of an additional 7% (computer time) and 2% and 24% (for targeting and card/device final product inspection) being material related. This represents a total of approximately 30% of production control time devoted to material issues in the card/device area and 28% in the targeting area. The Tech Mod project team reviewed this expenditure with the thought that improvements were possible through modifications in material handling and storage procedures and equipment.

It is estimated that, like the reduction in group leader time devoted to material activities, the same reductions can be accomplished with production control because the statusing and location of parts and assemblies is positively impacted by improved storage and location systems. This translates into a significant savings when extended to the total FM & TS operation.

Basically, the incorporation of tracking and handling systems for material will result in significant reductions in FM & TS manpower dedicated to these tasks. As is evident in the surveys conducted within the FM & TS organization, indirect support as it relates to material is a principal cost driver.

4.5 FM & TS Area Layouts

The following sections describe the "As-Is" layouts of the overall Honeywell FM & TS Production as well as specific layouts of the card/device and targeting areas. Figure 4.5-1 depicts the location of the card/device and targeting areas within the overall St. Louis Park facility. One of the more important features that can be noted by this layout is the great distances between the two remotely located areas which make up the card/device work center (from 250 to 300 feet for a typical inter-area trip).

In general, the area configurations are limited by irregular physical boundaries which inhibit the ability to design a straightforward work flow. Work "cells" or technology "clusters" are not able to be accomplished due to the work

ACTIVITY	Prod. Cont. # 1	Prod. Cont. # 2	Prod. Cont. # 3	Prod. Cont. # 4	Prod. Cont. # 5	Prod. Cont. # 6	Card/Dev. TOTAL	Card/Dev. AVERAGE
COORD PARTS	0.08	0.12	0.10	0.03	0.08	0.01	0.42	0.07
ISSUE PARTS/KITS	0.03	0.05	0.13	0.00	0.01	0.08	0.30	0.05
PART/KIT TRACK	0.05	0.17	0.19	0.07	0.06	0.21	0.75	0.13
MAT'L MGMT TIME	0.03	0.08	0.02	0.11	0.04	0.07	0.35	0.06
TOTAL MAT'L	0.19	0.42	0.44	0.21	0.19	0.37	1.82	0.30
ATTEND STATUS MTGS	0.07	0.07	0.01	0.03	0.06	0.00	0.24	0.04
FINAL PROD INSP	0.05	0.00	0.00	0.06	0.02	0.00	0.13	0.02
CUSTOMER TIME	0.06	0.00	0.11	0.00	0.01	0.02	0.20	0.03
CONTRACTS TIME	0.02	0.01	0.00	0.04	0.01	0.00	0.08	0.01
TELEPHONE	0.04	0.03	0.09	0.04	0.14	0.03	0.37	0.06
MEETINGS	0.01	0.00	0.01	0.01	0.03	0.02	0.08	0.01
TOTAL PROD	0.25	0.11	0.22	0.18	0.27	0.07	1.10	0.18
COMPUTER TIME	0.07	0.09	0.01	0.11	0.02	0.07	0.37	0.06
GROUP LEAD TIME	0.07	0.04	0.00	0.05	0.04	0.00	0.20	0.03
FLOOR SUPPORT	0.10	0.03	0.08	0.06	0.02	0.10	0.39	0.07
TRAINING	0.03	0.00	0.01	0.03	0.00	0.00	0.07	0.01
SORT/FILE/RETR	0.03	0.05	0.00	0.04	0.05	0.00	0.17	0.03
ENGR CORRESP	0.08	0.01	0.07	0.05	0.05	0.04	0.30	0.05
SPONT INTER	0.10	0.06	0.04	0.03	0.13	0.03	0.39	0.07
LABOR TICKET	0.03	0.05	0.00	0.02	0.01	0.08	0.19	0.03
ERRANDS	0.04	0.03	0.03	0.02	0.12	0.01	0.25	0.04
OTHER	0.00	0.14	0.08	0.20	0.09	0.23	0.74	0.12
TOTAL MISC	0.55	0.50	0.32	0.61	0.53	0.56	3.07	0.51
TOTAL ALL	0.99	1.03	0.98	1.00	0.99	1.00	5.99	1.00

Card/Device Production Control Labor Survey

Figure 4.4.3-1 Card/Device Production Control Labor Survey

ACTIVITY	Prod. Cont. #1	Prod. Cont. #2	Prod. Cont. #3	Prod. Cont. #4	Targeting TOTAL	Targeting AVERAGE
COORD PARTS	0.23	0.00	0.07	0.17	0.47	0.12
ISSUE PARTS/KITS	0.01	0.01	0.03	0.04	0.09	0.02
PART/KIT TRACK	0.04	0.16	0.02	0.12	0.34	0.09
MAT'L MGMT TIME	0.02	0.04	0.09	0.09	0.24	0.06
TOTAL MATERIAL	0.30	0.21	0.21	0.42	1.14	0.29
ATTEND STATUS MTGS	0.02	0.00	0.03	0.01	0.06	0.02
FINAL PROD INSP	0.02	0.03	0.02	0.00	0.07	0.02
CUSTOMER TIME	0.00	0.02	0.00	0.00	0.02	0.01
CONTRACTS TIME	0.04	0.02	0.00	0.00	0.06	0.02
TELEPHONE	0.02	0.07	0.15	0.05	0.29	0.07
MEETINGS	0.00	0.01	0.01	0.00	0.02	0.01
TOTAL PROD	0.10	0.15	0.21	0.06	0.52	0.13
COMPUTER TIME	0.04	0.03	0.09	0.10	0.26	0.07
GROUP LEAD TIME	0.00	0.13	0.00	0.00	0.13	0.03
FLOOR SUPPORT	0.07	0.10	0.14	0.16	0.47	0.12
TRAINING	0.22	0.00	0.01	0.00	0.23	0.06
SORT/FILE/RETR	0.02	0.11	0.02	0.02	0.17	0.04
ENGR CORRESP	0.05	0.11	0.08	0.07	0.31	0.08
SPONT INTER	0.04	0.10	0.09	0.08	0.31	0.08
LABOR TICKET	0.02	0.01	0.04	0.01	0,08	0.02
ERRANDS	0.01	0.05	0.04	0.03	0.13	0.03
OTHER	0.11	0.00	0.09	0.00	0.20	0.05
TOTAL MISC	0.58	0.64	0.60	0.47	2.29	0.57
TOTAL ALL	0.98	1.00	1.02	0.95	3.95	0.99

Targeting Production Control Labor Survey

Figure 4.4.3-2 Targeting Production Control Labor Survey

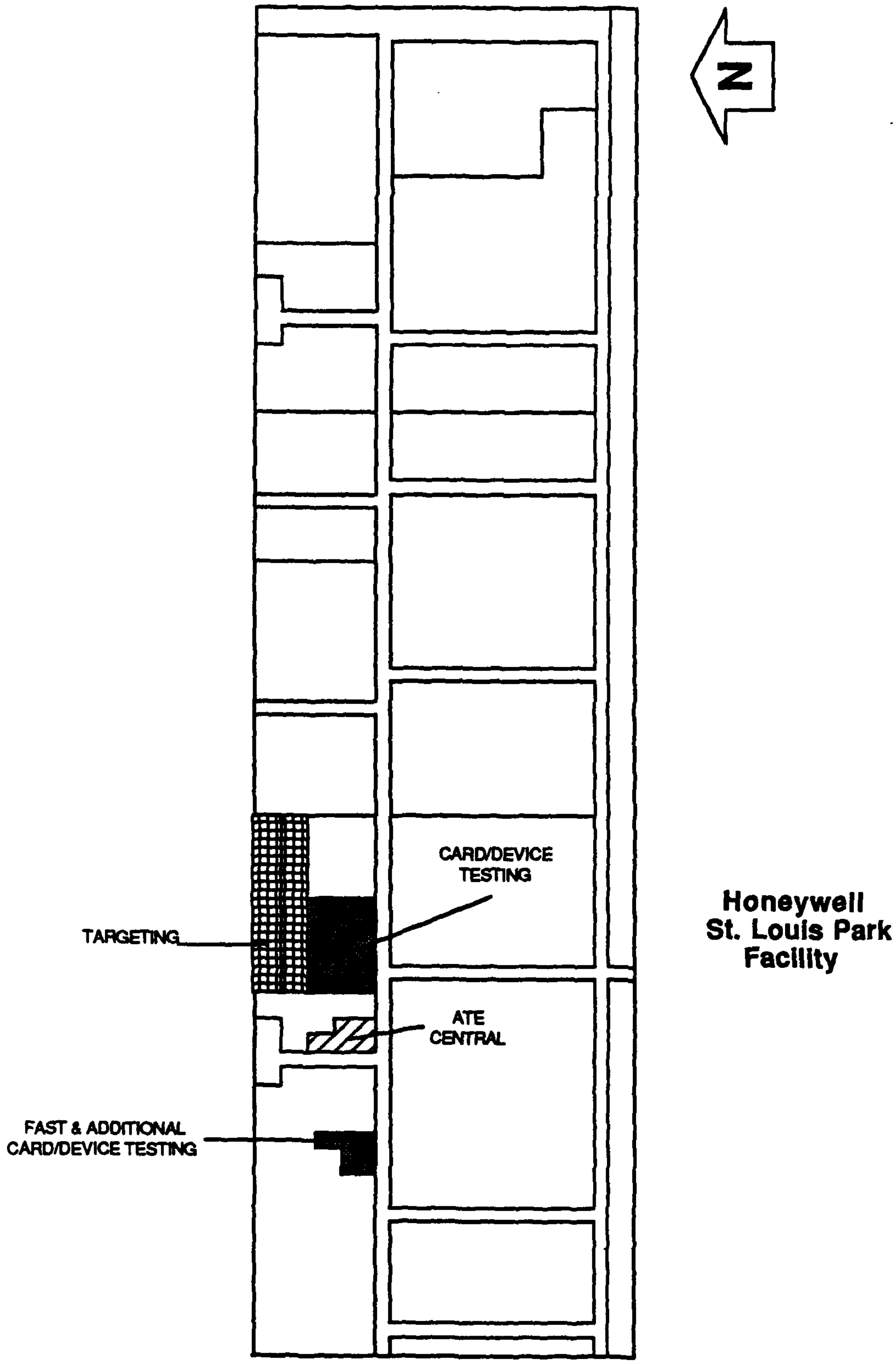


Figure 4.5-1 Card/Device and Targeting Areas "As-is" Locations

space limitations imposed by inefficient configurations and scattered storage modules.

4.5.1 Targeting Area Layout

The targeting area is shown in Figure 4.5.1-1. The functions within the targeting group can be divided by the following groupings although these groupings are not currently used to define specific "work cells". These groupings are:

- CRT Build
- Clean Room Operations [Boresight Reticle Unit (BRU) and Sensor Surveyor Unit (SSU)]
- Helmet Display Unit (HDU) Build
- Helmet Integration
- Integrated Helmet Unit (IHU) Cell
- Card Testing Cell
- Card Cage Assembly
- Darkroom
- Sub-Assembly Build
- Accuracy Station

The primary impedance to production flow can be seen from the layout of the targeting area. The production areas are grouped in a space that can barely accommodate the operations that are required and this greatly reduces the efficiency of the area.

4.5.2 Card/Device Area Layout

An overview of the card/device operations main area and the Final Assembly Support Team (FAST) area is shown in Figure 4.5.2-1. It is especially important to note that the operations performed by the card/device group are located in two geographically distinct areas. This requires the use of the stores group to move work across and down corridors and has a negative impact on production which is described in greater detail in Section 4.7.

4.6 FM & TS Production/Process Flow

Production flow is typically characterized by a combination of information flow, material flow, and process flow. For the purposes of this section, the concentration on production flow will be in regard to the specific area's process flow and subsequent sections will describe the material and information flows. The following paragraphs present an overview of the production flow in the card/device and targeting areas.

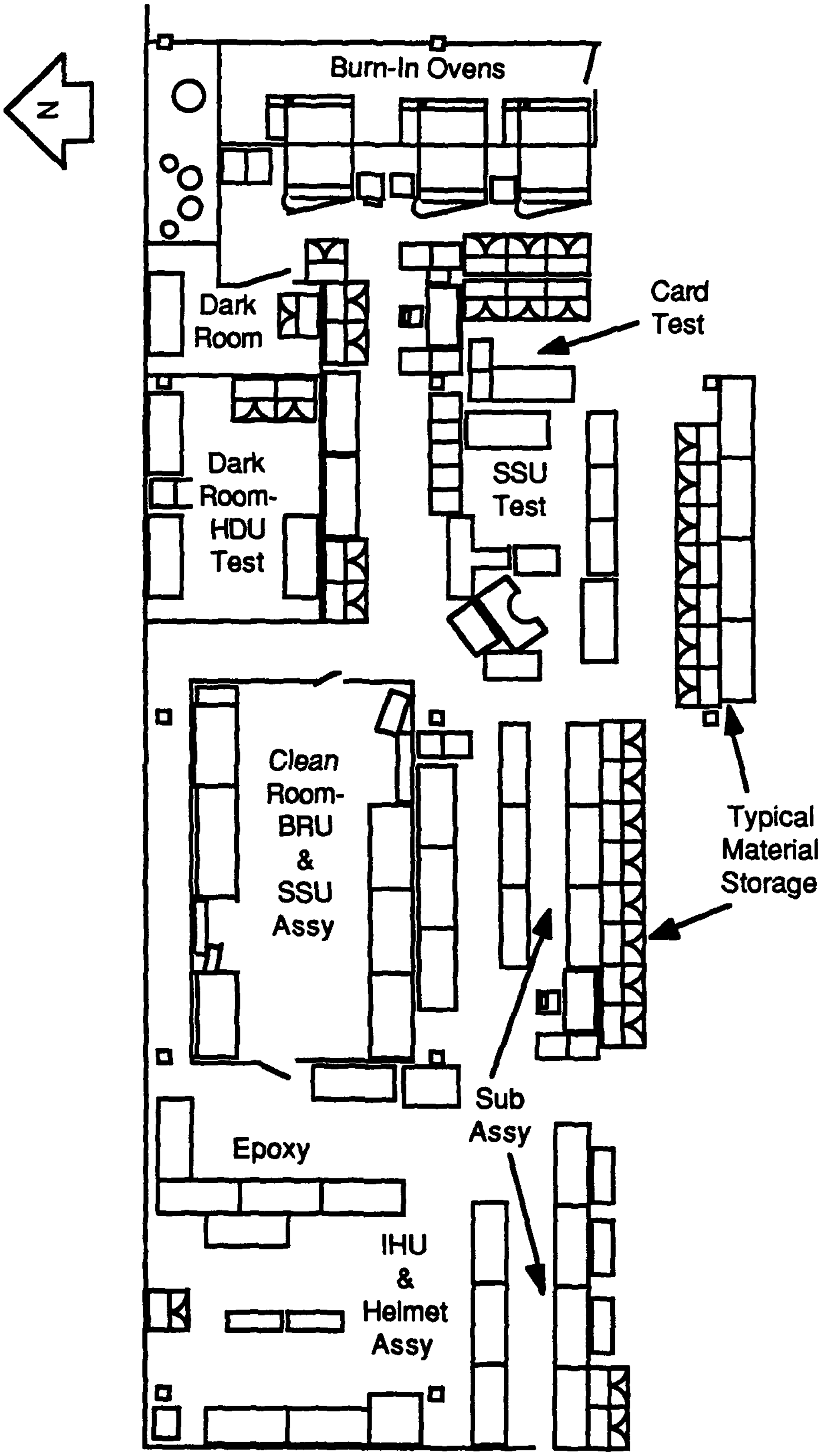


Figure 4.5.1-1 "As-Is" Targeting Area Layout

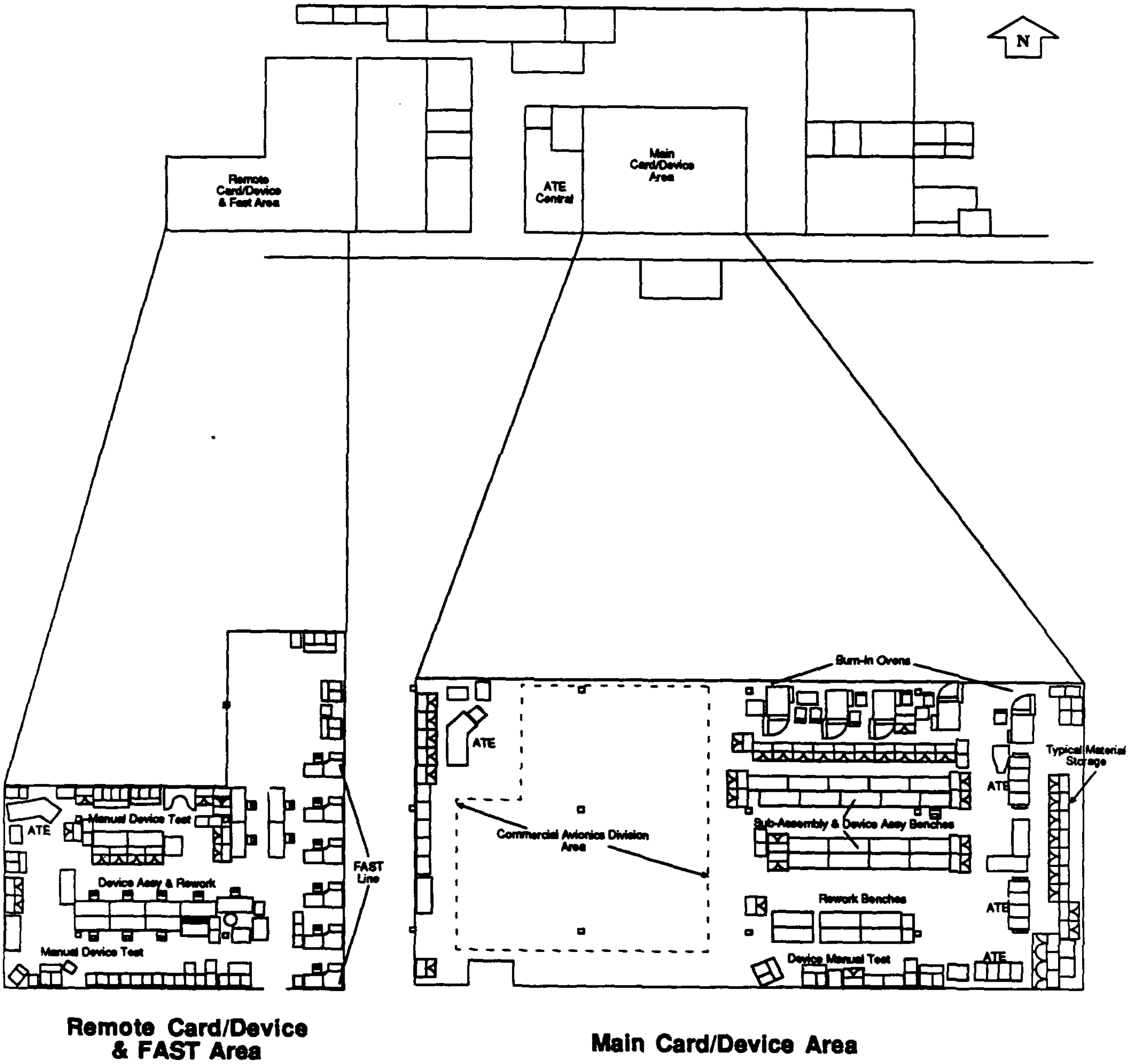


Figure 4.5.2-1 Card/Device Production "As-Is" Area Layouts

Within the card/device and targeting areas, the processing of electronic assemblies begins with card test and calibration. Circuit card assemblies (CCA) are received from an area located at the St. Louis Park facility which is dedicated to that function. The cards are first tested and any operational faults are detected and repaired. If a card requires the addition of a component to calibrate a specific circuit, the value is determined and the component is installed.

Once the card is fully functional, it is transported to the Paint and Coating area for a conformal coat. Subsequent to the coating operation, the card is stocked in the area for later inclusion in a device chassis.

If a specific CCA is intended to be shipped directly to the customer as a spare, it is retested and, if fully functional, presented to the inspection department for final approval prior to shipment.

As orders for devices are released, area personnel select the correct card complement from the stocking cabinets and install them in the chassis for testing.

Each device is run through a programmed checkout or pre-ATP (Acceptance Testing Procedure) on Automatic Test Equipment (ATE) to determine if it exhibits the correct functions in preparation for an environmental test (the exception to this is the major components of the Targeting Systems program which are checked out in system configuration lashups instead of individual ATE adapters). An Acceptance Test Procedure has been developed which each device must correctly pass to be a shippable unit.

Once the device is working properly, it is installed in an environmental chamber that subjects each unit to temperature cycling over a program specific period. Depending on the specific program, each unit will be subjected to either sinusoidal or random vibration during this burn-in period. Units requiring random vibration are transported to the Development & Evaluation (D & E) Labs for testing since the capability does not exist within the FM & TS Production area.

Device performance is monitored periodically during environmental testing and any malfunction requires that the device be removed from the chamber and be repaired.

Once the device satisfactorily passes the environmental test, it is run through a final ATP and accepted by quality and/or customer representatives. Final labeling and packaging completes the pre-ship procedures.

4.6.1 Card/Device Area Production/Process Flow

The card/device area process flow is graphically shown in Figure 4.6.1-1. In addition to developing the "generic" process flow depicted here, an

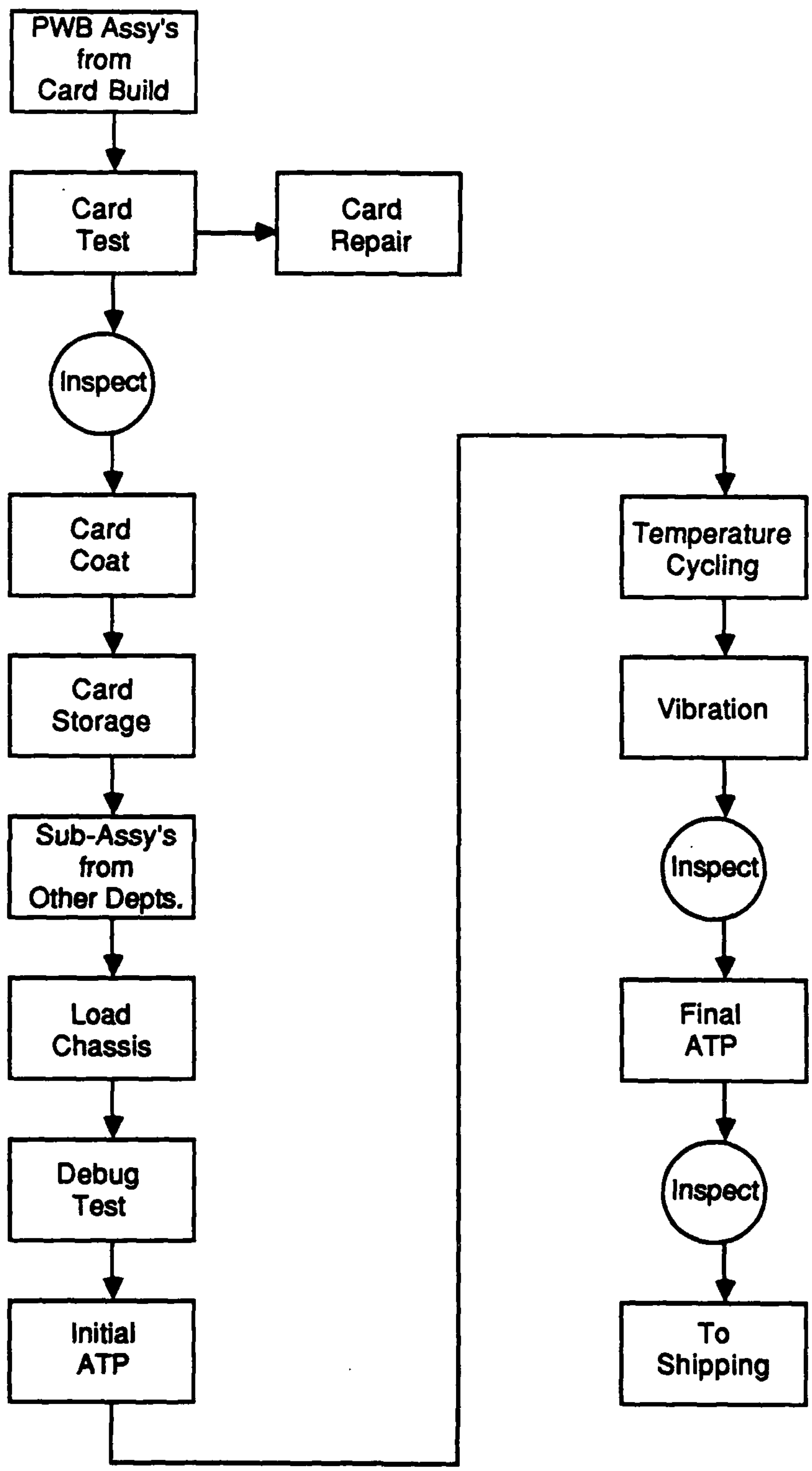


Figure 4.6.1-1 Card/Device Process Flow

operations/part number matrix (described in Sections 3 and 7) was developed to provide a more specific definition of the particular product flows in the card/device area. While Figure 4.6.1-1 highlights a relatively straightforward process flow from card test/card repair, card coat, and card storage to chassis loading, device testing, ATP, temperature and vibration cycling, and final ATP, the actual process flow within the physical environs of FM & TS is not carried out in as straightforward a manner.

The process flow in the card/device area can be characterized by a number of factors which impede an uninterrupted process or production flow. While major operations are performed at single workstations, the physical constraints of the card/device area are significantly different and unique from those in the targeting area. Primarily, the major physical constraint on the process flow for the card/device area is the geographic isolation of processes. As shown in Figure 4.5.2-1, the main test operations are located in one separated location and the FAST and some specific program assembly/test operations in another distinct location. This requires a great deal of manual tracking of production as well as the movement of production across corridors by the stores organization.

In addition, the geographic separation of the card/device areas increases queue time between processes and makes scheduling a much more time consuming task. Figures 4.6.1-2 and 4.6.1-3 present the production flows within each of the separate card/device areas.

In addition to the physical production flow constraints within the area, there is the additional restraint concerning inspection. The inspection area is remotely located from the process flow although not physically very far from the card/device production area. However, the location of the inspection area requires that work be diverted from the process flow to a dedicated inspection location to obtain the required certifications. Inherent in this diversion to a separated inspection area is the queue time required by the inspection area of approximately two hours (maximum).

4.6.2 Targeting Area Production/Process Flow

The targeting area is characterized by the fact that while there are specifically dedicated work surfaces for each group of distinct operations, there is excessive movement in the area to complete assembly operations from start to finish. As shown in Figure 4.6.2-1, there is a great deal of "backtracking" of production rather than a straight line flow dictated by processes.

Due to area physical constraints, work surfaces share several processes and work-in-process can be found in aisleways and next to benches on many wire carts. Operators are required to operate in confined quarters with bulky items such as helmet assemblies. The clean room, while essential to the processing of delicate targeting sub-assemblies, presents a physical obstacle to

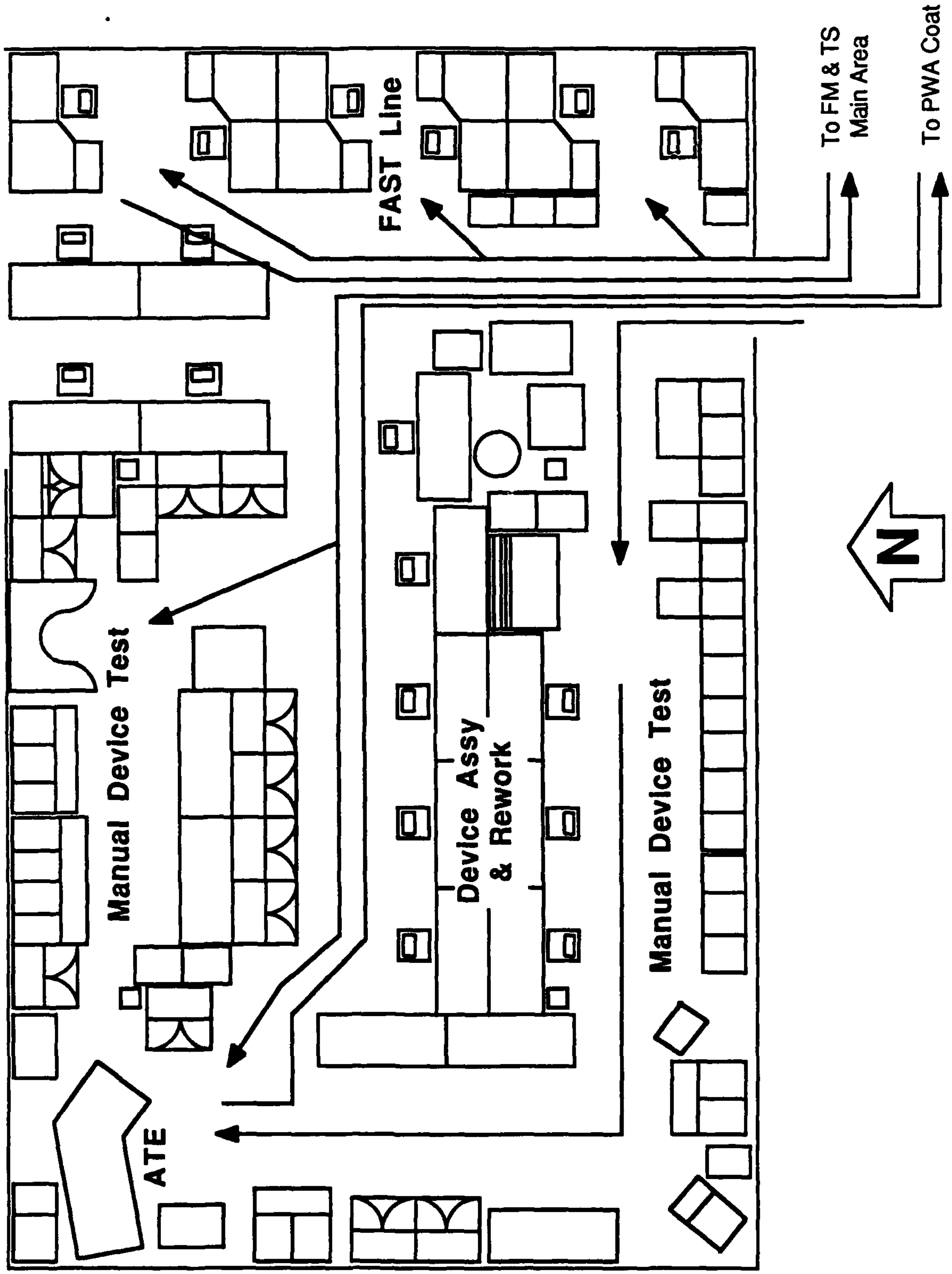


Figure 4.6.1-2 Remote Card/Device & FAST Production Flow

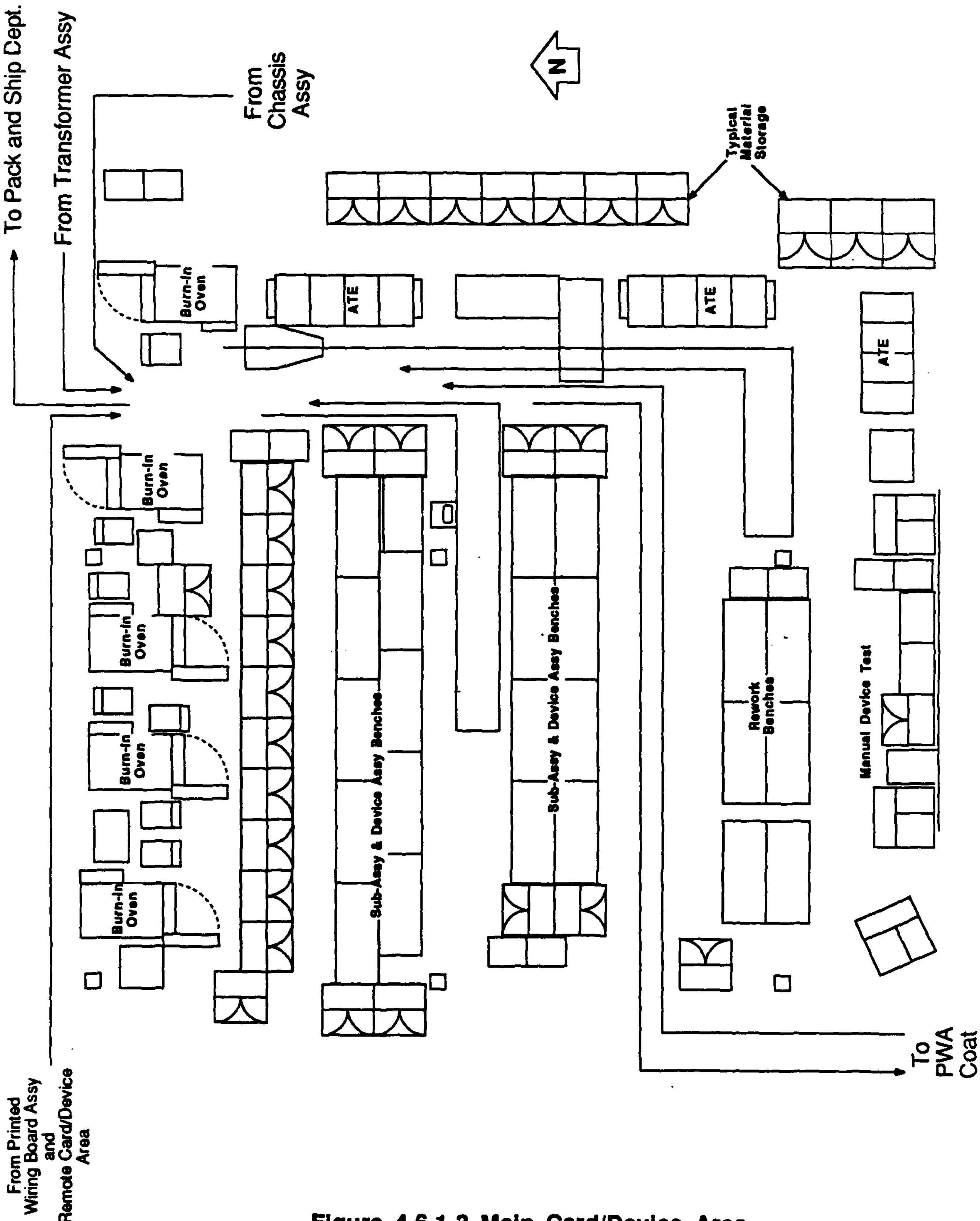


Figure 4.6.1-3 Main Card/Device Area Production Flow

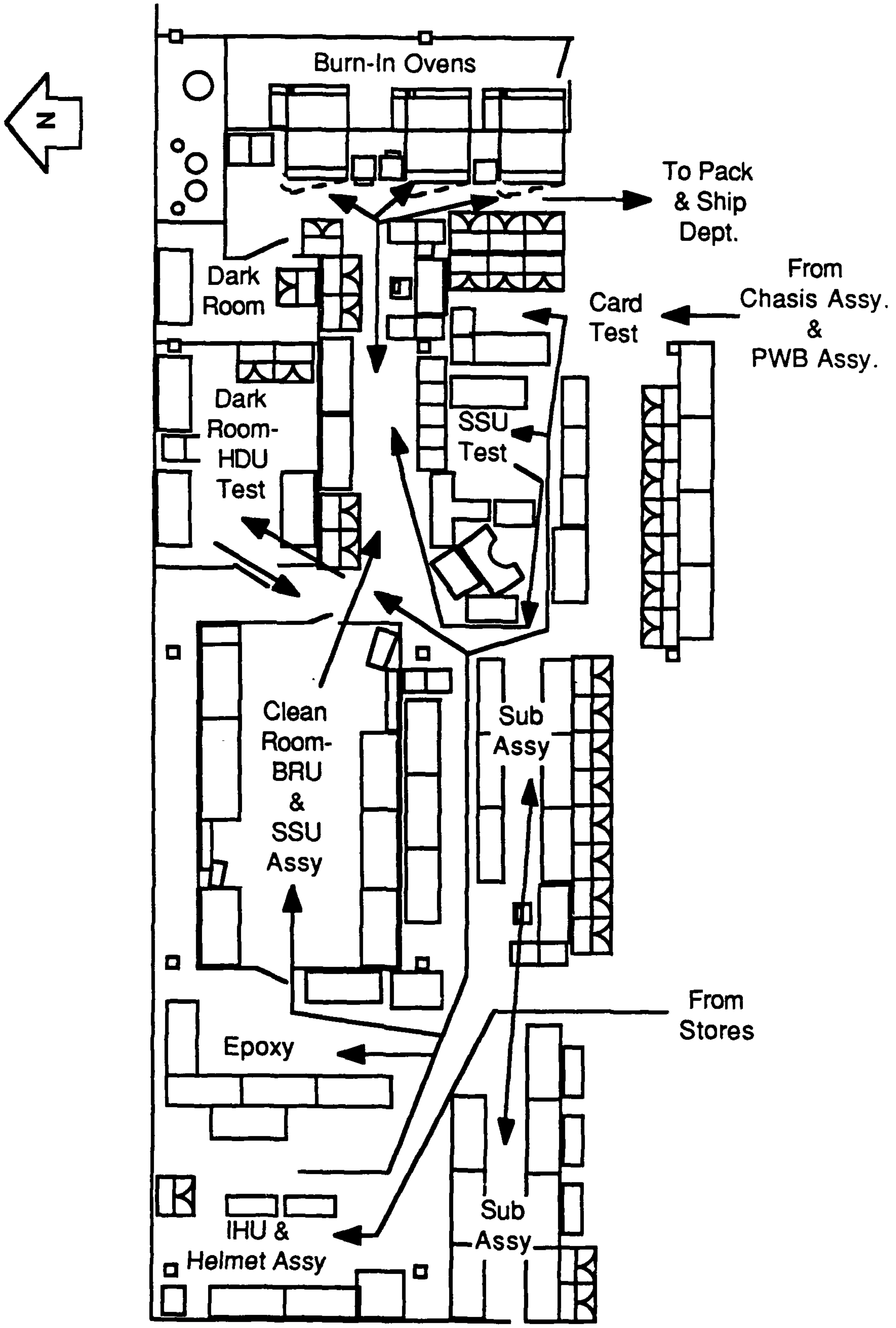


Figure 4.6.2-1 "As-Is" Targeting Production Flow

a smoother flowing assembly area. The situation is further complicated by the criss-cross production flow within the area.

Basically, the targeting assembly and test area is overcrowded, leading to production inefficiencies and the potential for lost and broken parts.

4.7 FM & TS Material Flow

The material flows for both the card/device and targeting areas are presented in the following section. In general, a number of characteristics can be stated regarding the card/device area material flow. One of the major impedances to a smooth material flow, also highlighted in the previous section discussing production flow, is that areas within the card/device operations are separated geographically. The impact of this on material handling is greatly magnified due to the fact that each of these areas is separated by an "aisle" which requires transport of work-in-process by the Honeywell stores organization.

The transport of material by the Honeywell stores organization not only incurs delays in the transit time between these areas but also presents several other factors, including:

1) Possibility of damage to work-in-process in transit between the various production areas

2) Increase in queue times from process to process

3) Inability to define exact scheduling parameters which requires additional carrying of inventory to assure product build

4) Additional efforts required for manually tracking material and work orders

5) Increase in lag time for operators transiting from area to area

The primary means of material movement, whether to other areas or internally within an area, is manual. While, manual material movement does not greatly impact the material flow, another feature of the areas does. This is the method for material storage.

Currently, material storage in the card/device and targeting areas is performed in a space wasting and time consuming manner. The primary storage areas are cabinets, shelves, racks, under counter of workbenches, and even on top of workbenches when all other space is unavailable.

In the card/device area "As-Is" configuration, over 1,300 cubic feet is devoted to storage of all types, including fixtures, queued material, work-in-

process, repair parts, etc. Also in the card/device area, material is transported manually by the group leaders or operators.

In the targeting area "As-Is" configuration, another 1300+ cubic feet is devoted to storage of work-in-process, card adapters, helmets, and related parts. The storage of all of these materials is contained in cabinets distributed throughout the operational areas. Large cabinets, "under bench top" shelves, and wire racks are used to store miscellaneous production materials. In total, there are over 50 individual storage locations within the three card/device and targeting operational areas.

4.8 FM & TS Information Flow

The information flow within the FM & TS card/device and targeting areas is a blend of manual and automated, or "computerized", systems. Primarily, the higher level systems (which are used company wide) are the systems which have been computerized and the controls and systems in place on the factory floor are primarily manual. The only exception to this distinction is the ATE Central (described separately in Section 4.9), an integrated testing facility whereby programs are downloaded to specific testing devices.

4.8.1 FM & TS Computerized Information Systems

The primary computerized information system currently at Honeywell is the GAPOS/BOS system. While this is currently in the process of being phased out and replaced by the HMS/BOS system, the functionality of the two systems appears to be approximately the same even though the HMS system will provide a more efficient and powerful computing environment.

GAPOS is a high level business system consisting of a total MRP financial-based computer system. Unlike HMS, GAPOS does not collect any data directly from the shop floor and all of the data transmitted to the shop floor is in the form of paper documentation.

The GAPOS system consists of several modules that are dedicated to specific areas within the system. A block diagram detailing the interrelationships of these modules is presented in Figure 4.8.1-1. The GAPOS system consists of several modules, including:

Bill of Materials which includes all part information for all products manufactured by FM & TS as well as the structures of those products.

Production Process which contains all of the operations descriptions for processes required for manufacturing at FM & TS as well as the production routings of those products.

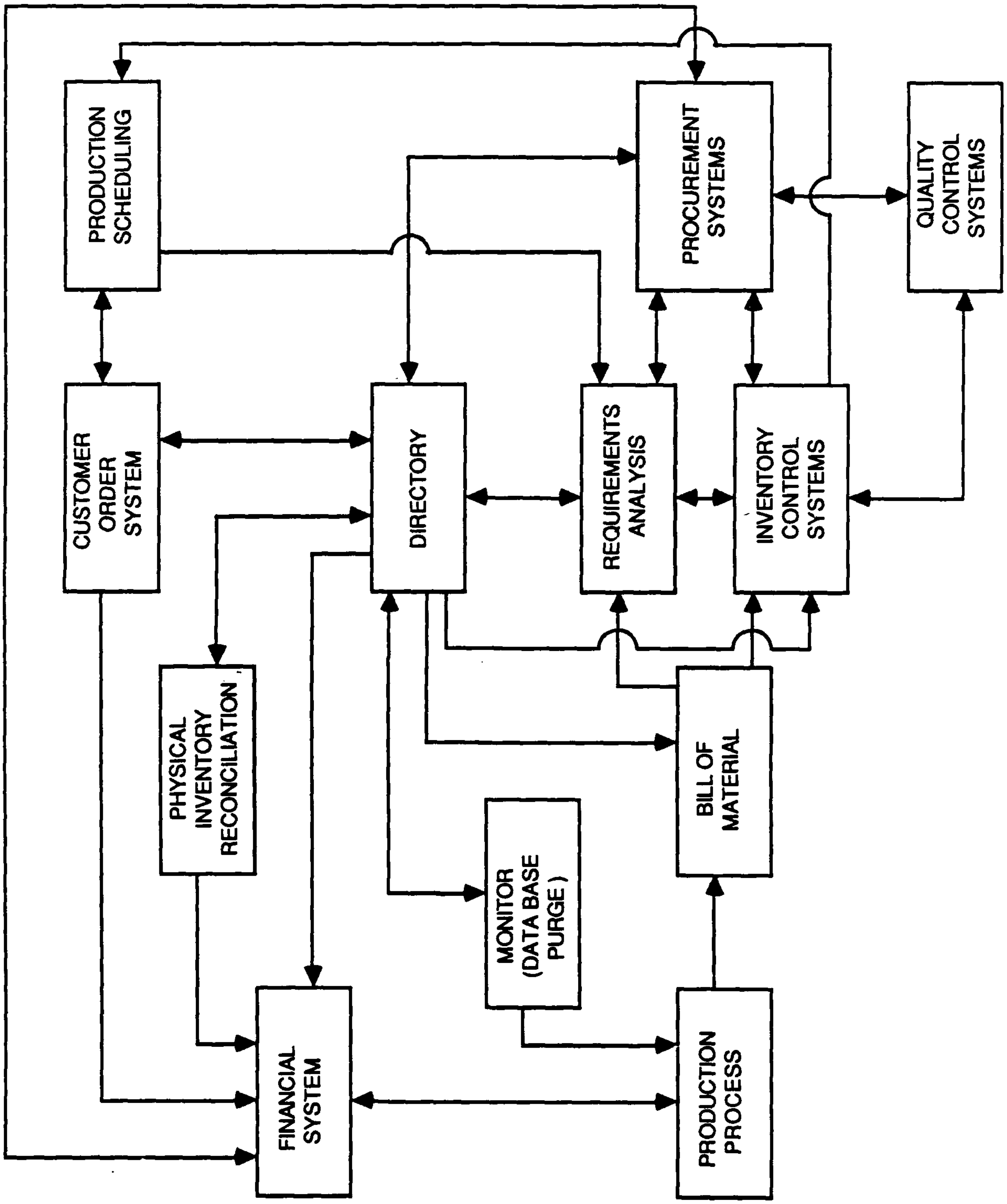


Figure 4.8.1-1 GAPOS System Block Diagram

Financial System which includes all areas concerned with general ledger, payroll, etc.

Procurement Systems which includes all vendor data, purchasing functions, etc.

Customer Order Schedule which processes all customer orders (both booked and forecast) and provides a summary of total product needs.

Production Schedule Analysis which summarizes customer order and marketing forecast requirements, calculates and updates schedules, allows for manual adjustment for leveling schedules and economic order quantities, provides input to Inventory Control Analysis module and promise feedback to Customer Order Scheduling, and records accomplishments against schedules.

Production Planning and Inventory Control modules which convert production schedules for devices and spare parts into requirements for component assemblies and parts and provides sub-assembly schedule requirements by week.

A more detailed description of the generation of the computerized schedules is provided in Figure 4.8.1-2. In this scenario, projected sales and booked orders are fed into the Customer Order System where they are processed and sent to the Production Schedule Analysis module. Here a schedule is generated for the completion of an end item ordered and the order is then released to the Requirements Analysis module which explodes the Bill of Material for all of the items scheduled and processes orders for the required materials.

Following processing by the Production Schedule Analysis module, the end-item schedule is sent to the Production Line Scheduler for manual balancing of the schedule for possible changes dependent upon schedule requirements already developed. The sub-assembly schedule, generated after the requirements analysis has been performed, is sent to Production Planning for the development of more discrete schedules and coordination of material delivery and manufacturing releases.

4.8.2 FMC & TS Manually Based Information Systems

Most of the systems utilized on the shop floor for such tasks as production tracking and control, inventory control, etc. are manual, paper-based systems. Manual tracking of work-in-process on the shop floor is performed utilizing several aids, including:

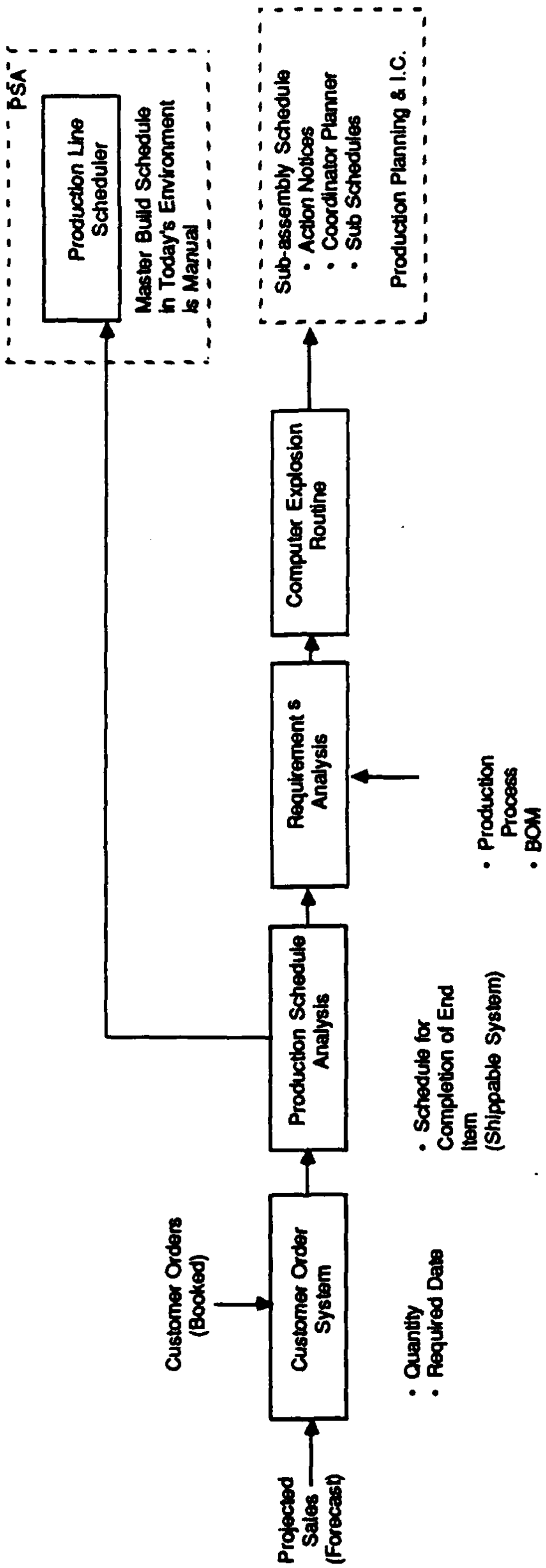


Figure 4.8.1-2 Computerized Schedule Generation

Mats. These are primarily scheduling status sheets which track the manufacture of sub-assemblies (characterized by a specific operation routing/layout sheet) by number of completions by scheduled lot. Production mats are the primary scheduling and tracking devices used on the shop floor.

Labor Tally Sheets. As their designation implies, these are used to track the labor charged for work on a specific sub-assembly or assembly as well as to track the type of work that was performed (i.e., manufacturing process, rework, troubleshooting).

Hot Lists. These are used to prioritize the processing of scheduled parts on the shop floor and include blue tags, red tags, and short interval scheduling lists.

The statusing information derived through the use of these production tracking aids is used as feedback to the GAPOS/BOS system. This feedback, however, only occurs at major completion intervals such as the completion of a finished sub-assembly or a device final assembly. This allows both for build-ahead (which results in increased inventory carrying on the shop floor) as well as stocking of finished sub-assemblies until they are scheduled to be completed.

Additionally, process data is recorded on the shop floor. Primarily, this is in the area of burn-in and test data. Burn-in data is, for the most part, manually generated and tabulated. Several ovens are equipped with temperature cycle recording, but this is not integrated between burn-in ovens and, more importantly, there is no direct feedback from an oven (apart from limit settings) when a programmed level is out of specification.

4.9 FM & TS Equipment

The equipment employed in the card/device area can be generally characterized as older (though proven) equipment that has remained in place for several years. In contrast, the equipment used in the targeting area is relatively newer. The primary reason for this disparity is the age of the programs, with the program which makes up most of the targeting area business being the newest major program initiated in the FM & TS area.

The following sections describe the equipment currently being used in manufacturing in both the FM & TS targeting and card/device areas. Included is a description of the equipment, applications, and other specifications as they apply to the specific pieces of equipment.

4.9.1 Test Equipment

The following section describes the test equipment currently used in Honeywell's FM & TS Production area. This equipment includes:

- ATE Consoles
- Fluke Circuit Board Tester
- Manual Test Consoles
- Environmental Chambers
- General Purpose Test Equipment
- Adapters for Cards, Devices, and Environmental Burn-In

A detailed description of each of the major equipment types is presented in the following subsections.

4.9.1.1 Honeywell Automatic Test Equipment

The Honeywell ATE unit is a programmable, computer controlled tester designed to automatically test electronic modules of varying complexity for functional compliance with specifications for voltage type, frequency, amplitude, time duration, logic state, etc. Under program control, it is capable of providing the necessary stimulus to a Unit Under Test (UUT) so as to properly exercise specific operational functions which may be automatically measured.

Hardware

The Honeywell ATE has been in use for production testing on FM & TS assemblies for over eighteen years. The ATE is a computer-controlled tester utilizing a stored program to exercise both modules (printed circuit assemblies) and devices (card cages or "black boxes"). The computer acts as the control point of the operations of various instruments in the system that provide stimulus to and measure response from a unit undergoing test.

The ATE units in use in the FM & TS area are primarily configured as analog testers. The Honeywell ATE is a multi-bay cabinet consisting of rack-mounted measurement instruments and stimulus devices (e.g., power supplies, signal generators, waveform generators, etc.) controlled through an instrument addressing scheme with stimulus and measurement values transmitted back and forth to the H-316 controller via binary or BCD coding. The instrument stimulus output and measurement input points are wired to a main receiver chassis which provides interconnection to units to be tested via an interface patch panel as directed by the respective test program.

Typically, a unit under test is interfaced to the ATE via an adapter which contains the necessary interconnection hardware to both mate with the unit under test and the receiver (or main interconnection panel) of the ATE unit. An additional function of the adapter is to provide the signal terminations and routings (as well as power connections) which are required by the unit under test.

Typically, each of the ATE units has the following programmable instruments:

- DC Signal Sources
- AC Signal Sources
- Function Generator
- Pulse Generator
- Decade Resistance Panel
- DC Power Supplies
- Digital Voltmeter
- Threshold Detector
- Time and Frequency Digitizer
- Time Delay Generator
- AC/DC Converter

Additionally, power supplies are provided to energize units undergoing test. These include:

- 28 VDC
- 115 VAC, 400 Hz, 3 Ø
- 26 VAC, 400 Hz

ATE Central

All Honeywell ATE units in use by FM & TS are connected to a program storage facility known as "ATE Central". This facility is located in close proximity to the main FM & TS production area and is shown in Figure 4.9.1.1-1. The current area supporting FM & TS ATE Central is made up of approximately 960

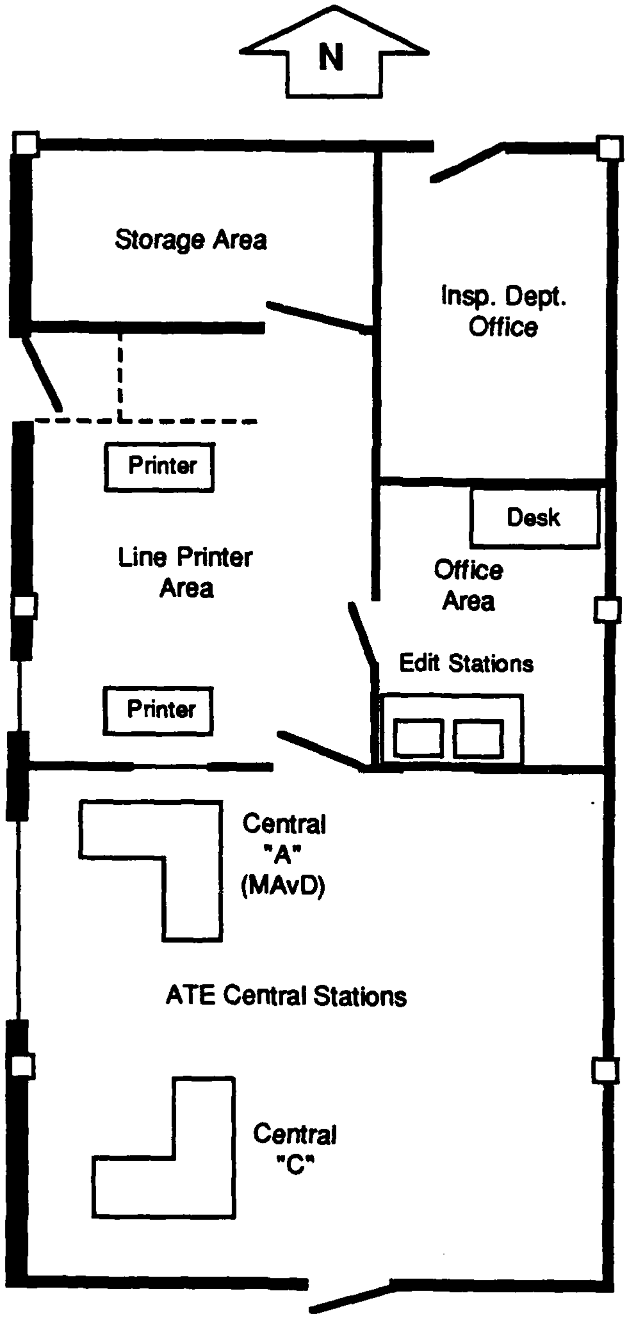


Figure 4.9.1.1-1 ATE Central "As-Is"

square feet. The facility is on an eight inch raised floor and has both temperature and humidity controls with smoke alarms and other protective devices.

ATE Central is the repository for all test programs executed on units undergoing test in the card and device areas. Depending upon memory size requirements, programs are downloaded totally (or in blocks) to the requesting test station when the part number - dash number is provided at the respective station. This provides a central control of program configuration and eliminates the possibility of operator modification of the program. Additionally, the Honeywell computers located in Test Central provide control for all other Honeywell testers on site.

Data logging is also performed by the system which provides summaries of test results to satisfy the documentation requirements of various contracts. These log sheets are obtained from line printers located in Test Central and are included with the data packages associated with each device tested.

Fixturing

As indicated previously, adapters are required to interface the Honeywell testers and units requiring testing. These can be divided into two major categories:

- Card Adapters
- Device Adapters

Card Adapters

Card adapters permit printed circuit assemblies to be tested on the ATE. The adapters contain the necessary mating connectors to interface the card with the tester.

In some cases, a "family" of cards can be tested on an adapter or on a main adapter with "Piggyback" connector modules, thereby minimizing adapter costs and complexity. Adapters for the ATE's have been developed and are in use for many programs.

Figure 4.9.1.1-2 presents the physical outlines of the majority of these adapters.

Device Adapters

Device adapters allow the "black boxes" (chassis loaded with cards) to be tested on the Honeywell ATE units. Programs for the devices are

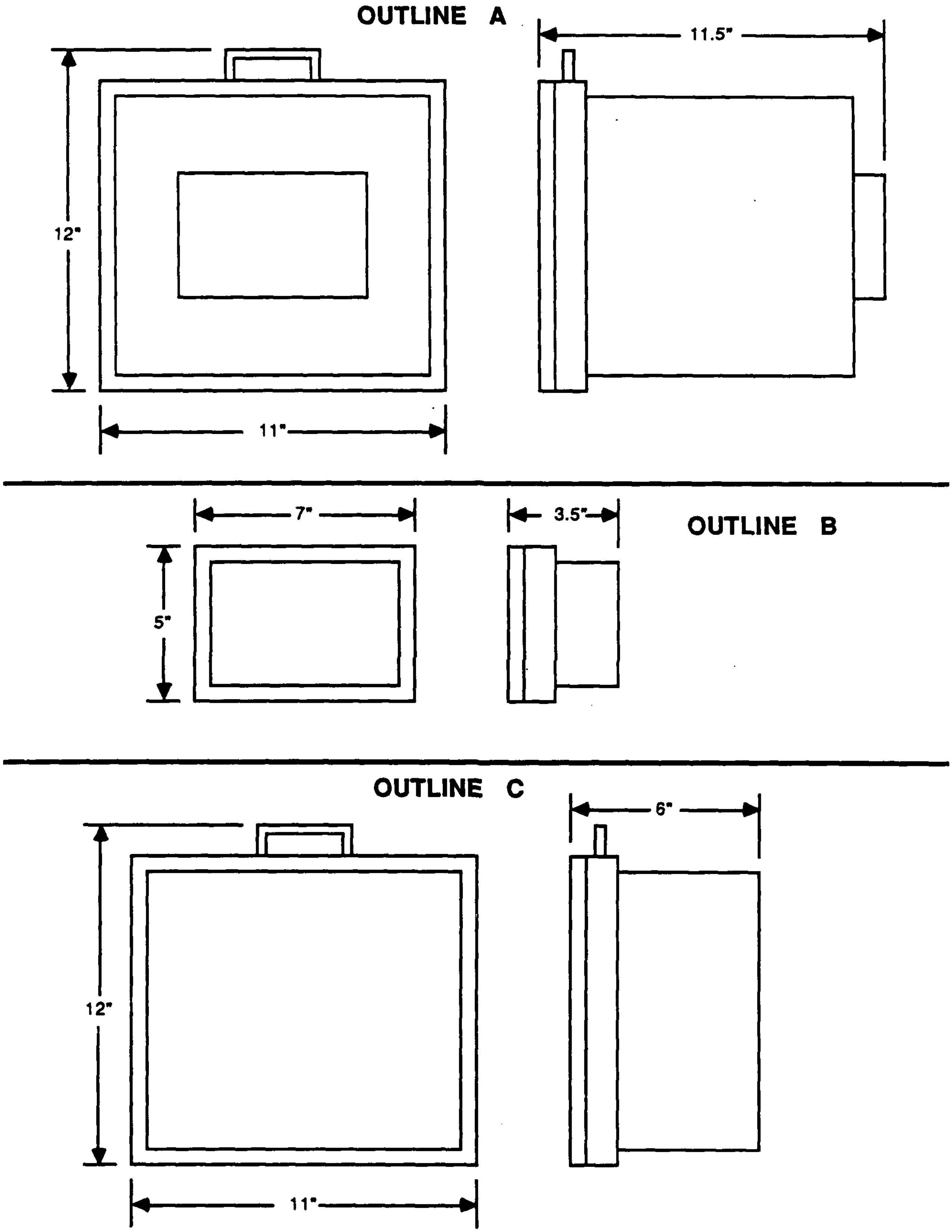
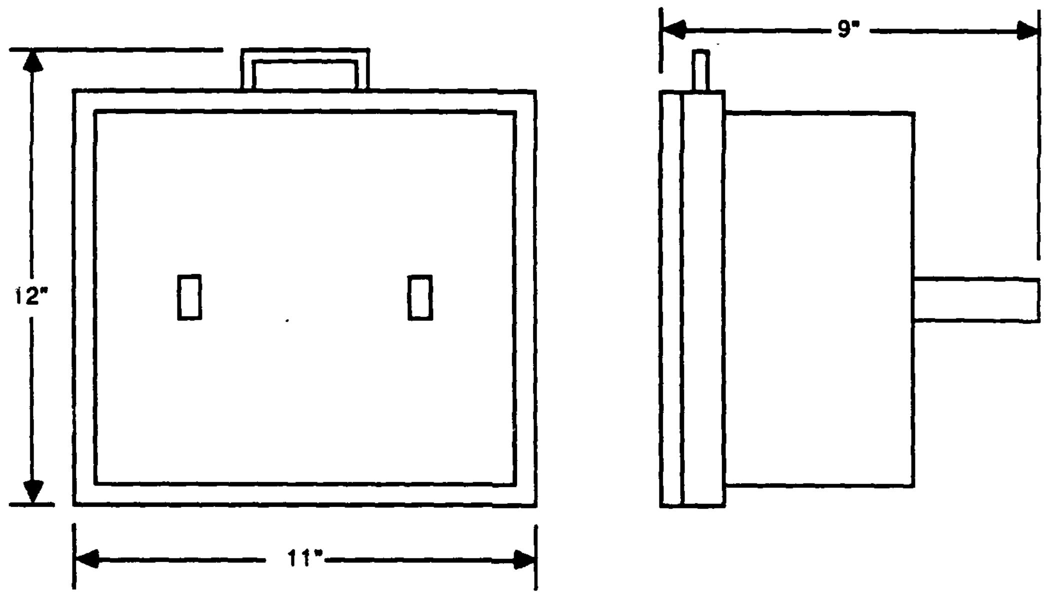


Figure 4.9.1.1-2 FM & TS Card Test Adapters

OUTLINE D



OUTLINE E

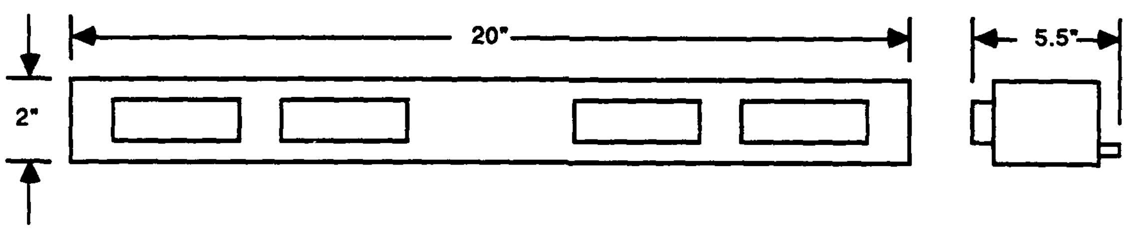


Figure 4.9.1.1-2 FM & TS Card Adapters (Cont.)

comprehensive and usually take from thirty minutes to an hour to execute to completion. The tests are loaded in blocks (or segments) because the tester memory is of limited capacity.

These tests are of considerable significance since they form the basis for the Acceptance Test Procedures (ATP) which must be successfully run on each device before and after environmental testing to permit final qualification and shipment. As indicated, printouts identifying the completion of a qualifying ATP run are produced by the ATE network and become part of the device documentation package.

Honeywell ATE Programming

Honeywell ATE programs can be divided into two basic categories: card programs and device programs.

Card programs tend to be shorter and less complex, requiring execution times ranging from seconds to a few minutes. In addition to testing card function, the tests allow circuit calibration by the insertion of a component value within a specific range to "trim" a circuit into the correct operational parameters. The operator can insert a value and run the test until the desired results are obtained.

Programs are generally straightforward and built up out of subroutines or subprograms which control the various signal and power sources within the ATE as well as the measurement modules which are provided. By inserting the specific conditions and values desired into the program coding, stimulus or measurement by the designated instrument is provided within the text sequence at the point desired.

For devices, the task is more complex. Since a device is a part of the Aircraft Flight Control System, the test program must simulate the environment, or range of conditions, the device will be expected to encounter while in operation. As a consequence, the ATE program must provide a complex variety of signal conditions to the device. Generally, these programs only require the operator to connect the unit to a properly functioning ATE station and start the program. As long as no failure occurs, intervention is unnecessary. While constant monitoring is not required, programs do not provide much more information upon failure than out-of-limits parameters. As a consequence, considerable experience with both cards and devices is necessary to effect rapid repairs.

In programming, the process is essentially manual, requiring the establishment of required parameters line-by-line in test station code. As previously indicated, instrument subroutines assist the programming effort, but coding, debug, and certification depend heavily on the expertise of the programmer.

4.9.1.2 Fluke Automatic Tester

Since the Honeywell ATE has limited digital card testing capabilities, FM & TS began digital card program development and testing on a Fluke Functional Test System in 1979. This tester was acquired by the Commercial Avionics Division and has been available to FM & TS on an off-shift basis for shared use testing of digital cards since that time. However, as the Commercial Avionics Division completes their move to a new facility, this tester will become unavailable.

Hardware

The Fluke Functional Tester is primarily a digital tester utilizing a comparison testing technique to determine the condition of a card of unknown functionality. This is accomplished by exercising a "known good" card of an identical type in parallel with the unknown card. Essentially, both cards are stimulated identically, in time and pattern, and the output response compared step-for-step. If no difference is detected, the unknown card is determined to be good.

The tester is basically a desktop console with display and control facilities capable of controlling cards with a maximum of 240 input and output pins (the Honeywell unit was configured for 128 pins). Zero insertion force connectors are provided to interface with adapters which in turn provide the interface with the UUT. The console has a built-in floppy disk unit to store the card test programs which can be prepared off-line. The disk drive also permits the testing of cards with a large number of test steps by linking program segments.

Two accessory units for the tester are available to FM & TS to assist in programming and testing cards:

- Analog Test Station
- Off-Line Programming Station

The analog test station is a rack-mounted group of instruments consisting of a counter/timer, multimeter, function generator, programmable power supplies, and a switch matrix module. This unit is interfaced with the Functional Tester to permit testing of cards with mixed digital and analog (hybrid) circuitry. The instrumentation is controlled via an IEEE command set and programs are developed on a separate programming station.

The off-line programming station permits development of card test software and minimizes interference with testing activities. The unit is a desktop console with CRT and keyboard and has two floppy disk drives to allow

program storage, transfer, and duplication. Once a program is developed, debugging and certification proceeds on the Functional Tester.

Networking

This equipment has the capability of being interconnected to a centralized program database similar to the Honeywell ATE's and ATE Central, however this function is not utilized at present. This activity could be performed via RS-232 protocol and interconnection.

Fixturing

All fixturing for the Fluke Functional Tester consists of adapters to interface the tester with various cards utilizing digital signal processing. The adapters contain the necessary internal wiring to correctly route signals to and from the card under test and the tester. They are relatively simple to wire and comparatively inexpensive to build.

Programs

Programs for the Fluke Functional Tester can be developed on the tester or on the off-line programming station. Selection of data rates, input and output pins, digital patterns, logic levels, etc. are set up to operate the card being tested under program control. Program options allow a wide variation in stimuli to ensure that all devices on the card are exercised sufficiently to detect any functional failures.

The Fluke tester, as opposed to the Honeywell ATE, is able to exercise digital circuits at much higher rates of speed which more closely approach those encountered in system operation. Moreover, the Fluke Functional Tester has much greater digital capability than any other card tester available to FM & TS operations at this time. The chief disadvantage to FM & TS is access to this equipment, since it resides in the Commercial Avionics Division card testing area and FM & TS Production receives a low priority for use of the system. Furthermore, this tester is scheduled to move with the Commercial Avionics Division to its new off-site location in the near future.

4.9.1.3 Manual Test Consoles

As part of program development, several consoles or test stations have been constructed to assist primarily in testing devices. The test consoles allow testing and troubleshooting of cards and devices without tying up the ATE units in prolonged diagnostic operations. As might be surmised, the testers are special purpose units with some having standardized test equipment such as oscilloscopes and digital multimeters built into the test racks.

4.9.2 Burn-In Equipment

Typically, each contract for FM & TS systems has requirements for environmental testing which include time, temperature cycling, power application, vibrational conditions, etc. pursuant to applicable military standards. The equipment and processes described in this section are the primary means of ensuring contractual compliance in FM & TS environmental testing.

4.9.2.1 Environmental Chambers

As part of qualifying devices for the various programs currently in production in FM & TS, temperature cycling is required to verify performance under varying environmental conditions.

The ovens used to perform this testing are primarily units manufactured by Thermotron. Depending upon acquisition date, the oven controllers range from paper tape-sequencer to microprocessor controlled units. The ovens have integral charting recorders to indicate program sequence and log temperature data as part of the historical records accompanying each device.

As the ovens are loaded with a device for a new run, the cycle is initiated and a new chart is mounted. Progress is periodically monitored to determine if device function is correct as well as oven performance. This is essentially a manual operation requiring the physical monitoring of each individual oven.

4.9.2.2 Vibration Testing

Some environmental chambers in the card and device area are equipped with sinusoidal vibration tables to provide a simulation of operational conditions during device burn-in. Periodically during device burn-in, the vibration tables are activated under sequencer control to vibrate the unit.

The some programs currently in production in FM & TS specify random vibration operation during burn-in. FM & TS utilizes environmental chambers in the D & E Labs to perform these functions as required by contract.

4.9.2.3 Fixtures

In addition to the control consoles which are connected to devices undergoing burn-in, FM & TS has a complement of fixtures which are used to burn-in spare cards and other sub-assemblies. These fixtures allow production

personnel to perform the necessary environmental testing without the investment in a device chassis and complement of cards.

4.9.3 Targeting Equipment

The targeting area utilizes several automated test equipment set-ups to perform checks on various components of the system. Cards utilized in the SSU and devices are tested on a Honeywell ATE station. Major sub-assemblies are tested on the accuracy station which is a microcomputer-controlled performance tester used to conduct acceptance testing in targeting. Additional microcomputer controlled equipment is employed in CRT testing and evaluating the display sub-system in the darkrooms.

Overall, targeting test equipment is up-to-date and considerably automated. Since the system requires calibration and operation to a high degree of accuracy, the automation of testing is an essential element.

SECTION 5

"TO-BE" PROCESS

The following section describes the "To-Be" processes that will be in place as a direct result of ITM Project 80.

The primary emphasis of ITM Project 80 is on the improvement of material handling systems and equipment as well as the relayout of the FM & TS card/device and targeting areas. Other areas described in this section include:

- Production/Process Flow
- Material Flow
- Information Flow

5.1 "To-Be" Operations Overview

The "To-Be" operations for the card/device and targeting areas include improvements in the layout and material handling methods used in the areas as well as improvements in production, assembly, and test equipment described in the following section. While all improvements are described in general in this section, the emphasis of the following section is upon improvements resulting from relayout activities and material handling efficiencies.

Figure 5.1-1 presents an overview of the "To-Be" processes required to produce FM & TS products.

5.2 FM & TS Area Floor Plans

The preliminary floor plan design began with an evaluation of three factors:

- Product volume
- Processes employed
- Product flows

Product Volume

The product volumes were derived and matrix data developed from 1986 card/device and targeting area completion records. Where applicable, model (or program) identification was maintained. It was also necessary to validate the matrix data with product quantities and standard-to-actual ratios. This effort would provide a benchmark for determining headcount by comparison of 1986 totals obtained from different sources. Additionally, marketing data provided a

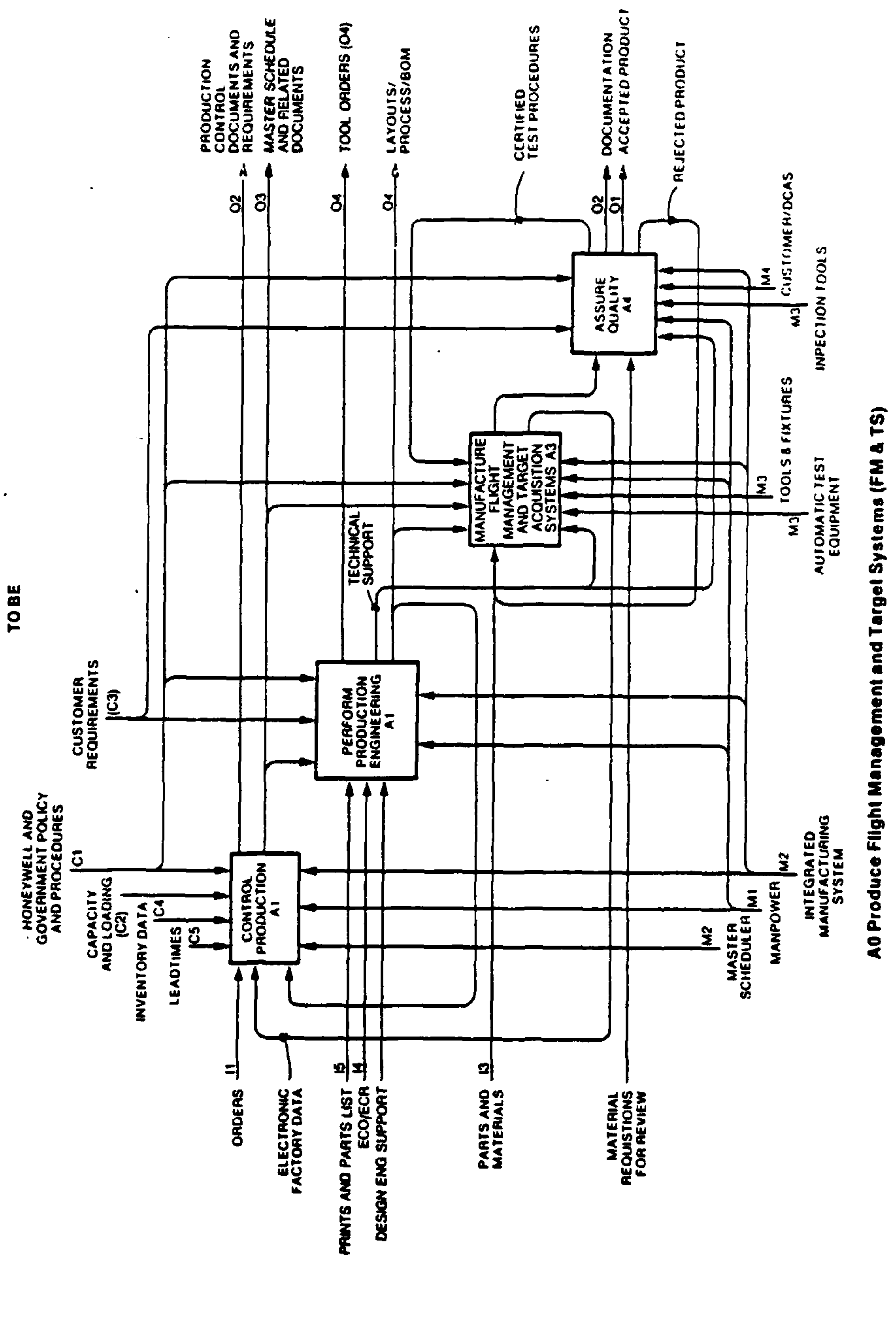


Figure 5.1-1 "To-Be" Production Process (FM&TS)

projection of future years' expectations and an estimate of space required to accommodate growth.

The aforementioned combination yielded a projected headcount figure over the project duration and identification of gross workstation space.

Processes Employed

The matrix (referred to above) also permitted a grouping of the same or similar operations. These were then reviewed to determine combinations of tools and/or skills which were capable of being combined.

As an example, the result in the targeting area was the establishment of process oriented stations, through which all unique assemblies and sub-assemblies pass, as dictated by the processing each requires. This permits the grouping of resources necessary to complete processing of a particular sub-assembly.

In the card/device area, operations were clustered by product/program. This approach concentrates manpower resources on specific products to assure technical expertise and a higher level of quality.

Product Flows

A major goal of ITM Project 80 was the consolidation of areas. In the card/device and targeting areas, significant unnecessary travel is dictated by location of areas within the St. Louis Park facility as well as the internal layout of those areas. The preliminary design addressed those flows and that resulted in significantly altered floor layouts.

Design Formulation

The combination of the previously mentioned volume, processes, and flows resulted in a preliminary plan for the targeting area which essentially had a linear flow. Material entered and was successively processed in various stations in a "straight-line" fashion. This resulted in an average flow distance reduction of more than 20% over the "As-Is" configuration. The design was also reviewed with alternative workstation arrangements to provide personnel with optimized work surface design.

The card/device flow was centered around product/program testing and burn-in, but there, however, substantial efficiencies were obtained by the integration of all product associated operations in one area. Most significant is the ability to direct all card/device activities in one place and optimize personnel resources while minimizing time lost traveling from area to area. Considerable savings in flow distance, requiring the utilization of stores personnel, was

achieved by integration of the remote card/device/FAST area with the main card/device area.

The "To-Be" floor plan showing the location of the card/device and targeting areas with respect to one another is shown in Figure 5.2.-1. Also shown in Figure 5.2.-1 is the location of ATE Central and the assembly/test area for the Digital Engine Pressure Ratio Transducer (DEPRT), a program which is not a part of ITM Project 80. Figure 5.2.-2 depicts the location of the "To-Be" card/device and targeting areas within the overall Honeywell St. Louis Park facility.

5.2.1 Card/Device Area Floor Plan

The floor plan for the card/device area is presented in Figure 5.2.1-1 and can be characterized as providing the following features:

1) Wide aisles have been included to facilitate the ease of work flow.

2) The area has been organized into major program cells.

3) Printed Circuit Card testing has been clustered with a centralized adapter storage.

4) Storage of work-in-process and supplies is consolidated in a single VS/RS unit.

5) An area has been provided for a new tester and related support services.

6) Spare work bench surfaces are distributed to allow for work load peaks and new product development areas.

7) The card/device area has been located near an aisle to provide ready access for outside work delivery as the need arises.

8) Burn-In ovens have been grouped in a common isolated structure to eliminate environmental impacts (vibration, noise, heat).

9) All FM & TS ovens are located in one area for ease of service and to provide free access for both card/device and targeting operations. Specialized utilities (chilled water, power) are concentrated and isolated in a single structure.

10) The FAST line is conveniently located to support card/device activities.

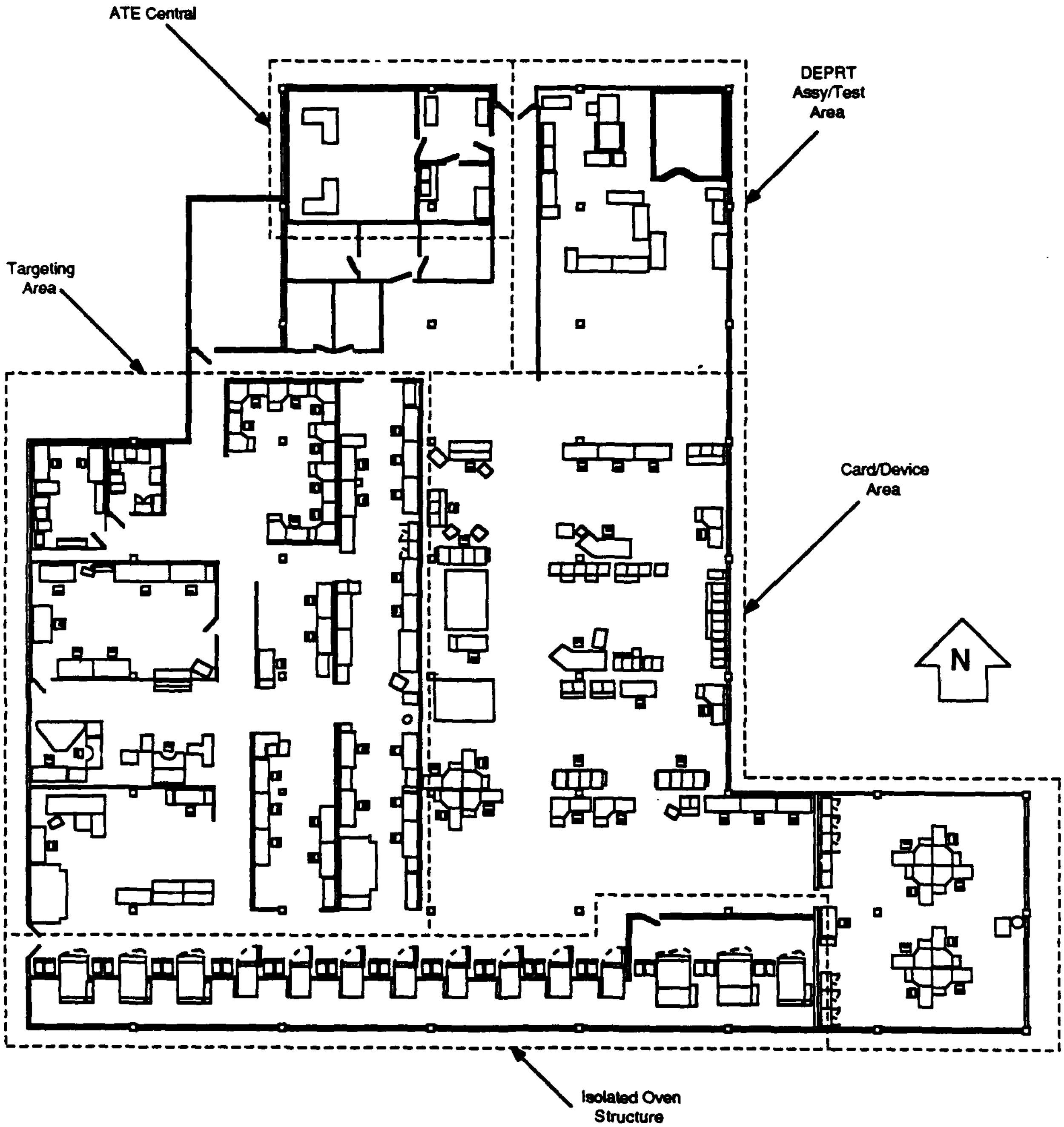


Figure 5.2-1 "To-Be" FM & TS Layout

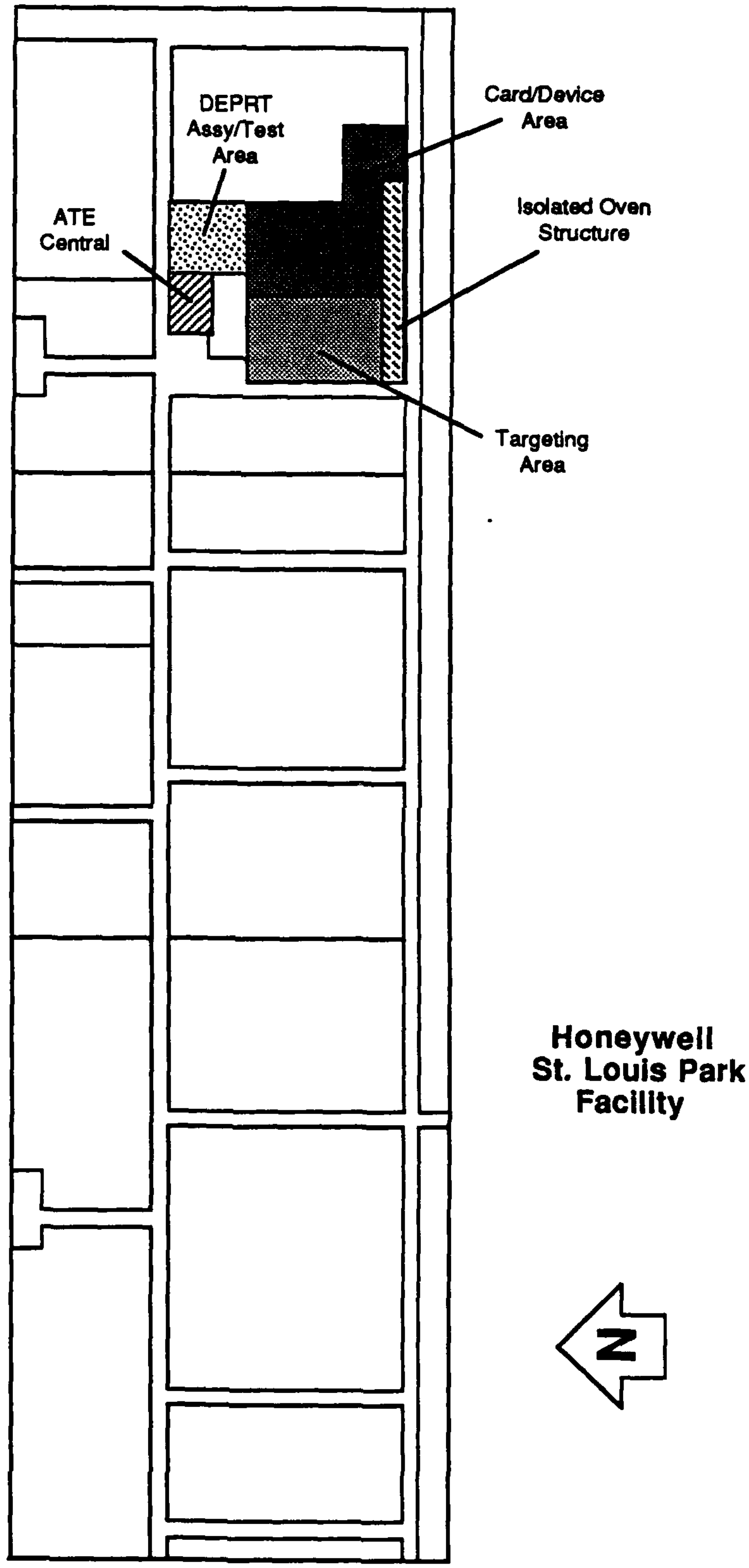


Figure 5.2-2 Card/Device and Targeting Areas "To-Be" Location

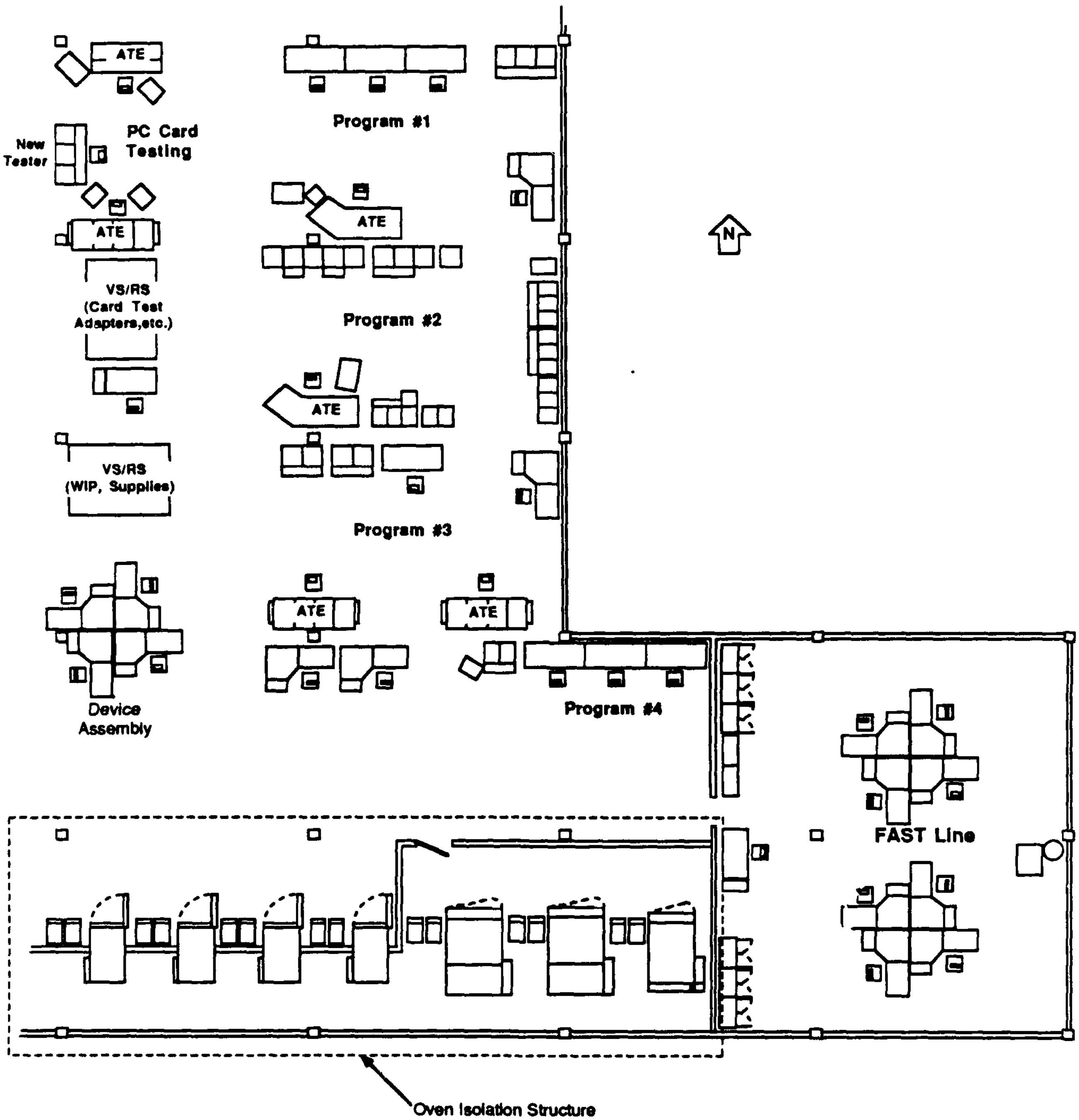


Figure 5.2.1-1 "To-Be" Card/Device Area Layout

11) In general, large cells and oversize aisleways allow addition of equipment or programs without crowding. The area has an expansion capacity of over one-third to accommodate increased production and future programs.

The major factors emphasized in the proposed floor plan include a more "free-form" environment with wider spacing, work place arrangements that promote greater operator interface, and work and materials storage is provided in close proximity to their point of use.

The proposed floor plan provides for a significant reduction of flow distance within the area. While this reduction is not necessarily a significant cost driver for evaluating the improved card/device area arrangement, the non-quantifiable improvements in efficiency, reduction of material movement required by Group Leaders, elimination of product movement by stores personnel, and several other factors support this improved layout.

5.2.2 Targeting Area Floor Plan

The floor plan developed for the targeting area is presented in Figure 5.2.2-1 and can be characterized as providing the following features:

1) The targeting area is laid out to provide a relatively smooth flow from operation to operation.

2) The layout is configured with more than adequate aisle space so that variations in process requirements from assembly to assembly do not pose significant flow problems.

3) The clean room is enlarged four to five feet in width (providing an increase of over 100 sq. ft.) to improve flow and reduce crowding.

4) One VS/RS unit is positioned in close proximity to the helmet build area to store raw materials, work-in-process, and finished helmet assemblies.

5) The second VS/RS is located near the testing operations to provide supplies support, and adapter and work-in-process storage.

6) The epoxy/curing area is centralized for ease of access from assembly cells.

7) CRT sub-assembly and testing are arranged in close proximity.

8) Ovens have been grouped in a common isolated structure to eliminate environmental (vibration, noise, and heat) impacts.

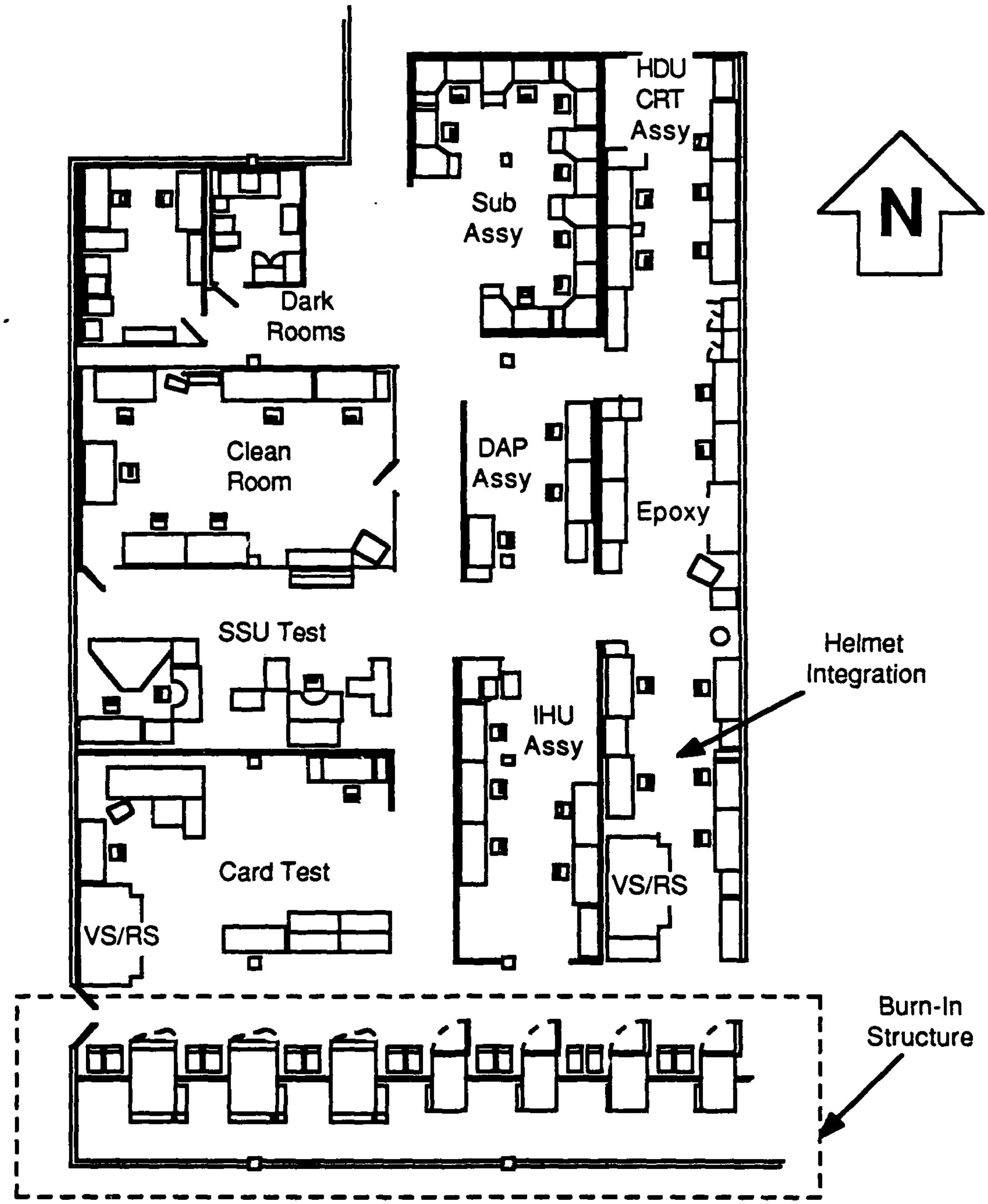


Figure 5.2.2-1 "To-Be" Targeting Area Layout

9) All FM & TS ovens are located in one area for ease of service and to provide free access for both card/device and targeting operations. Specialized utilities (chilled water, power) are concentrated and isolated in a single structure.

10) Testing activities are centralized to reduce transport distance.

The major factors emphasized in the proposed floor plan include more consolidated operations, major improvements in work flow, work place arrangements that promote greater operator interface, and work and materials storage are provided in close proximity to their point of use.

The proposed floor plan does not provide for a significant reduction in flow distance. The major benefit of the relayout is in eliminating clutter, backtracking, and congestion. While this is not necessarily a significant cost driver for evaluating the improved targeting area arrangement, the non-quantifiable improvements in efficiency and the reduction of material movement required by Group Leaders and stores personnel support this improved layout.

5.3 "To-Be" Production/Process Flow

The "To-Be" production/process flow is presented in the following sections. One of the major improvements in the optimized design of the production/process flow for each of the areas is the development of a straightforward production flow that is aligned with the process flow. Additionally, in the card/device area, the consolidation of the geographically distinct operations will result in significant production flow improvements.

5.3.1 Card/Device Area Production/Process Flow

As a result of the FM & TS relayout, activities related to card/device test and burn-in are consolidated in one area. This will allow testing of all devices to be performed in the same area as burn-in operations.

In the "As-Is" arrangement, area constraints require that some testing take place in a satellite area. This necessitates transporting units back and forth between areas for burn-in and repair/retest.

In the "To-Be" arrangement, external transport is eliminated. This minimizes delays in getting units into work and allows more uniform scheduling of labor resources. Additional area is provided as a "drop-off" point for material entering each cell.

Additionally, all card testing is consolidated to avoid the transport and scheduling delays associated with having the Fluke ATE in the Commercial Division card area. This has been resolved by proposing that FM & TS purchase a dedicated Fluke Automated Tester.

5.3.2 Targeting Area Production/Process Flow

As a result of the FM & TS relayout activities related to the targeting area, assembly and test are relocated to one area 95 percent larger than previously occupied. This permits each process to be located in a manner which enhances production flow.

All sub-assembly activities supporting major targeting assembly production are located in the production area, facilitating utilization of operator resources.

In addition to improving circulation throughout the targoting production area, additional space is provided in the "clean" room to reduce congestion and improve flow in that area.

5.4 "To-Be" Material Flow

The improvements in the "To-Be" material flow are presented in the following paragraphs. In general, a number of characteristics can be stated regarding the improvements in both the card/device and targeting areas. The most important improvements in the material handling for both of the areas involves the methods and equipment used for material and fixturing storage.

5.4.1 "To-Be" Targeting Area Material Flow

The targeting area material flow will be significantly improved through the implementation of two major types of material handling and storage devices. These are:

- Vertical Storage and Retrieval Systems (VS/RS)
- Dedicated Material Handling Carts

This equipment is described in detail in the following subsections.

5.4.1.1 Vertical Storage and Retrieval Systems (VS/RS)

In the current targeting area configuration, over 1300 cubic feet is devoted to storage of all types, including helmets, supplies, queued material,

work-in-process, repair parts, etc. In gross numbers, over a third of material currently stored is helmets and helmet-related work-in-process due to the bulky nature of the part itself.

In the "To-Be" targeting area operations, a majority of all of the material in these work areas will be stored in Vertical Storage and Retrieval Systems (VS/RS). VS/RS units are automated, micro-processor based storage and retrieval systems which occupy small footprints of space. Items are stored in pans which travel following a vertical enclosed loop track. Pans are brought to work counter height via the shortest route. An operator does not have to bend, search, or grow fatigued looking for an item, therefore improving productivity.

These systems will reduce the floor space utilized for storage significantly and consolidate material into specific areas adjacent to the materials' points of use which reduces the material movement travel time. It will also assist group leaders and operators by significantly reducing the time associated with locating materials.

It is proposed that one VS/RS be oriented near the helmet assembly area. The second VS/RS will be utilized for the storage of card assemblies, card adapters, and other device-related work-in-process items.

Another significant improvement associated with the implementation of the VS/RS units is the addition of a purchased computer-driven material locating system for each of the VS/RS units in the areas. While many users require a simple "go to pan" operation, to take full advantage of these units, a storage and retrieval locating system is proposed. This will serve to eliminate excessive time required to search for the appropriate materials and more optimized utilization of the storage devices.

5.4.1.2 Dedicated Material Handling Carts

In the proposed plan, material would be transported throughout the work area on carts with a very limited number of shelves and closeable/lockable doors. The major premise behind this is to only have material on the shop floor that is being worked on and all other materials stored in a defined location. Since work-in-process storage could potentially occupy approximately 500 or more cubic feet in the Vertical Storage and Retrieval System, improved material handling disciplines must be established to avoid "hiding" excess material in a VS/RS.

The benefit of limiting work-in-process storage to carts (with work-in-process in the VS/RS stored due to lack of materials to complete the job or as completed sub-assemblies) is that which is actually "in-process" will be readily apparent. [The Japanese liken this method to that of draining a pond to make the bottom a smooth surface. As water is taken away, the largest rocks appear first. As each rock (or unnecessarily stored item) is removed, the pond is further drained until all of the rocks are removed.]

By not providing unlimited and hidden storage areas, problems related to timely delivery of kitted parts, etc. will surface and be more effectively dealt with.

5.4.2 "To-Be" Card/Device Area Material Flow

The card/device area material flow will be significantly improved through the implementation of Vertical Storage and Retrieval Systems. Currently, the storage of all materials in the card/device area is in a variety of cabinets distributed throughout operational areas. The greatest amount of cabinet space is assigned to store tested cards and card adapters. In other areas, there are 42 large cabinets and over 30 "under bench top" shelves used for storage. In total, there are 80 -individual storage locations totaling over 1300 cubic feet.

By establishing two VS/RS units, this storage space can be centralized for material presently spread around the areas. Furthermore, easier storage and retrieval will be made possible via the automatic locater system described in the previous "To-Be" targeting Area Material Flow section.

The VS/RS unit will increase floor space utilization by concentrating a greater amount of cubic storage in one area through the use of three additional feet of height. By bringing material to a usable height for placement/retrieval, spaces which are normally wasted in cabinets (near the floor or above an operator's head) are reclaimed for use. A ten foot high VS/RS can make available 350 cubic feet of storage in a space that tall cabinets can only provide 190 cubic feet, an increase of 84%. Additionally, travel distance with a VS/RS is cut to one-quarter to access the equivalent volume. The use of two VS/RS units in the card/device area reduces the cubic foot storage volume by approximately 550 cubic feet.

The proposed integrated and consolidated card/device area will contain two VS/RS units. These will serve the main activity areas of card test adapters and device sub-assembly work-in-process. This will provide supplies closely coupled to the point of use. Also, since card adapters are estimated to take up all of one VS/RS unit, the proximity of the other will permit any excess demand to be accommodated in the work-in-process VS/RS.

As an additional benefit in the future, the VS/RS equipment is capable of integration into the overall information management system.

5.5 "To-Be" Information Flow

The most significant improvements in the card/device and targeting areas information flow will be achieved with the introduction of the HMS/BOS system currently being modified for use at the St. Louis Park facility. While on a conceptual level this system performs all of the same processes as the GAPOS system, the increase in functionality is significant. Because the two systems are

similar in the types of functions they will be performing and the final definition of the system has yet to be implemented, the focus of this section will be primarily on the introduction of the Factory Data Collection system and the improvements outlined in this report that can be even further upgraded due to their selection for interfacing with a work center controller.

The Factory Data Collection (FDC) system has been developed as a means of automatically recording hours an employee expends on a specific operation/part number. This provides important information to FM & TS management both for accounting purposes as well as monitoring the percentage of completion of a specific part or unit being built. It is envisioned that in the future, the FDC system will be expanded to provide location tracking of work-in-process as well.

It is proposed that at some point in the future the Vertical Storage and Retrieval Locator System will be interfaced to HMS/BOS, either directly (which is not recommended) or through another system such as the Factory Data Collection System. This would provide a more integrated material tracking system.

One other program which is currently under evaluaticn for Honeywell's MAvD is the introduction of a "Factoryvision" system (ITM Project 32) which will present production layouts and other production related information to each of the operators on the shop floor. This type of system, interfaced with a work center controller would raise Honeywell's operations to the most advanced, state-of-the-art achievable with the computing technology available today.

5.6 "To-Be" Equipment

The following section describes the equipment proposed for implementation in the FM & TS card/device and targeting areas. This equipment significantly improves the operations in these areas and provides for the operations of these areas on a higher level of automation with, in some cases, the upward compatibility to an advanced work center controller being considered for future implementation.

5.6.1 Material Handling Equipment Improvements/Upgrades

There are two main material handling equipment improvements or upgrades that are presented in the "To-Be" operations in the card/device and targeting areas that affect the overall work area design. This equipment includes:

- Vertical Storage and Retrieval Units
- Material Handling Carts

5.6.2 Workstation Improvements/Upgrades

Considerable interest has been generated in the electronic manufacturing community over the past few years over improving productivity in the workplace. The FM & TS organization has been evaluating and incorporating some newer, modular workstations into its operations to improve productivity through better arrangement and efficiency at the work surface.

The Tech Mod project team has reviewed several styles of workstations in an effort to determine the most suitable configuration and arrangement which will enhance productivity. The team was assisted in this effort by the findings of the U. S. Navy Electronics Manufacturing Productivity Facility (EMPF) in their study of several types of workstations.

The EMPF, in a study that included both male and female subjects involved in electronic assembly activities, concluded that the most productive environment for workers occurs when the operator is placed in a modular work space with minimal opportunity for visual distraction. The study found that the elimination of "eye contact" in the work environment contributed 22% to the overall productivity of subjects involved in electronic assembly activities, thus allowing concentration on assigned tasks.

The Tech Mod team also reviewed various workstation configurations which could potentially take advantage of the EMPF study results. Two main arrangements were derived that allowed both efficient work flow and economical arrangement:

- Work Cells
- Bench Clusters

The work cell may consist of two or three benches arranged to provide a straight line flow as products are passed through a series of steps in the cell. This arrangement generally conserves floor space and provides linear external flow lines.

The second configuration is a four bench "cluster" which, while requiring external circulation to move work from station to station, benefits from requiring a singular utility drop thereby allowing economical installation and relocation. This arrangement allows what FM & TS Production management feels are beneficial operator groupings to accomplish similar or sequence related tasks. Utilizing this type of workstation grouping resulted in a reduction of thirty-four percent in flow distances for the card/device area.

The Tech Mod team also reviewed bench styles and construction details from several manufacturers. While most bench manufacturers employ components formed from cold-rolled steel tubing, some utilize aluminum alloy materials which are more than durable enough for the types of activities and weights encountered in electronic assembly, and which offer attractive cost savings in implementation.

5.6.3 "To-Be" Burn-In Operations

Burn-in will be comprised of a number of improvements including more environmentally isolated ovens which will provide consolidated access for servicing, a consolidated oven structure to contain heat and noise in a single structure, and individual oven isolation on the floor to reduce vibration dissemination as well as additional noise.

Additionally, the burn-in operations will benefit from the introduction of an oven monitoring network (part of ITM Project 82), which will record oven performance data automatically and provide a signal for out of tolerance conditions. This may be upgraded in the future to automatically control the ovens, also.

5.6.3.1 Oven Isolation Structure

Currently, the ovens in use in the FM & TS card/device and targeting operations are divided into several locations throughout the areas. In the "To-Be" operations, the ovens will be consolidated in one area along the south wall of the proposed site within the St. Louis Park facility (see Figures 5.6.3.1-1 and 5.6.3.1-2).

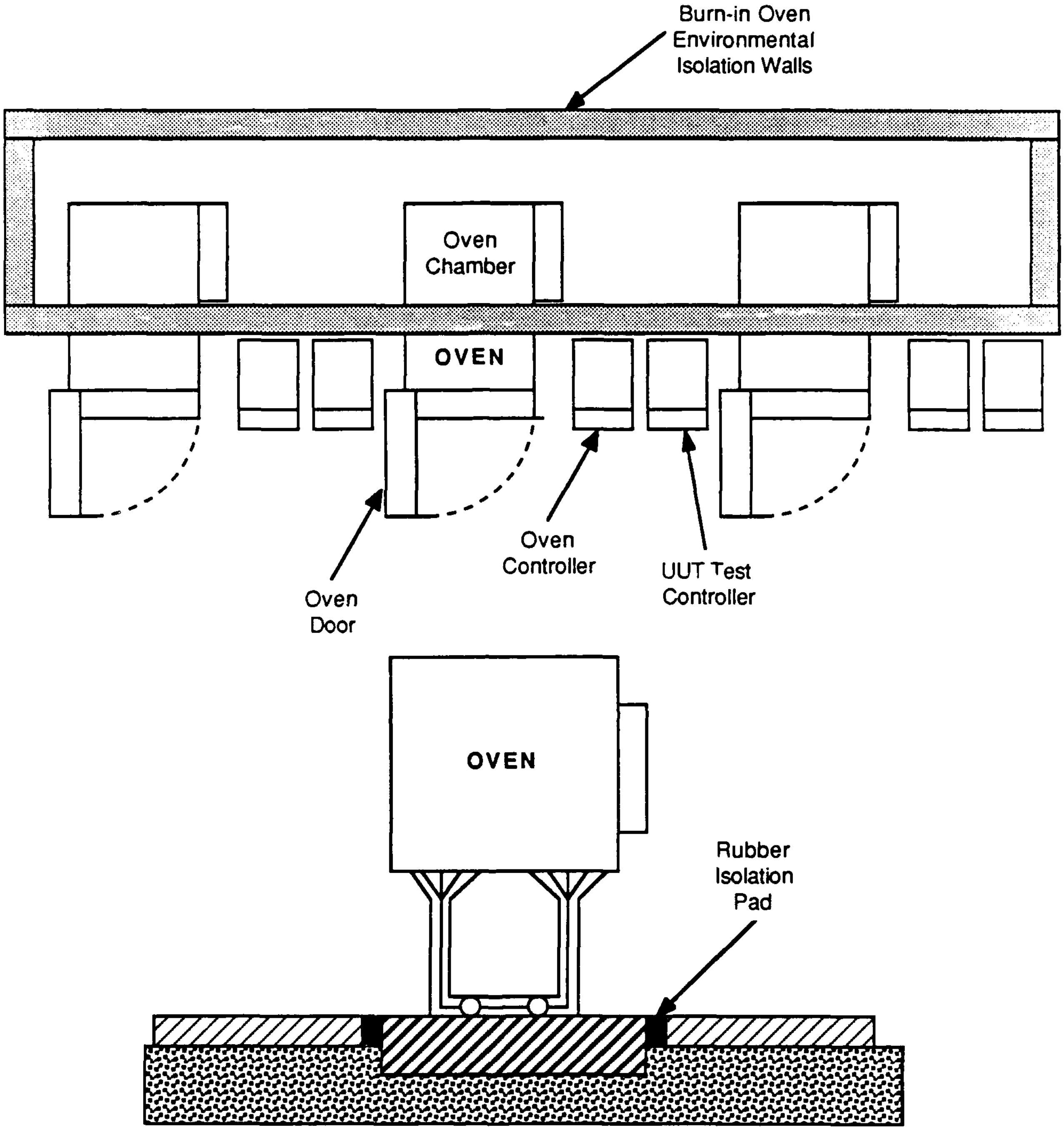
The installation of FM & TS ovens into one integrated structure provides several environmental benefits, including:

- Reduced operating noise
- Reduced vibration transmission
- Virtual elimination of heat gain in working area

The centralization of all of the ovens will also provide for the elimination of remote sites and the improved ability to load, monitor, and adjust the ovens.

The consolidated oven structure provides improved servicing and maintenance where work at the back of the ovens does not impair testing operations. Typically, as seen in the targeting area, the oven isolation approach creates a significantly improved work environment by reducing heat and machinery noise.

The addition of the separate mounting pad further reduces the transmission of vibration and allows these units to be located in close proximity to other testing activities.



(Oven and Vibration Unit sit on extra thick concrete slab, isolated from Main Floor. Rubber is wedged in joint between "floating" slab and Main Floor)

Figure 5.6.3.1-1 Oven Isolation Structure

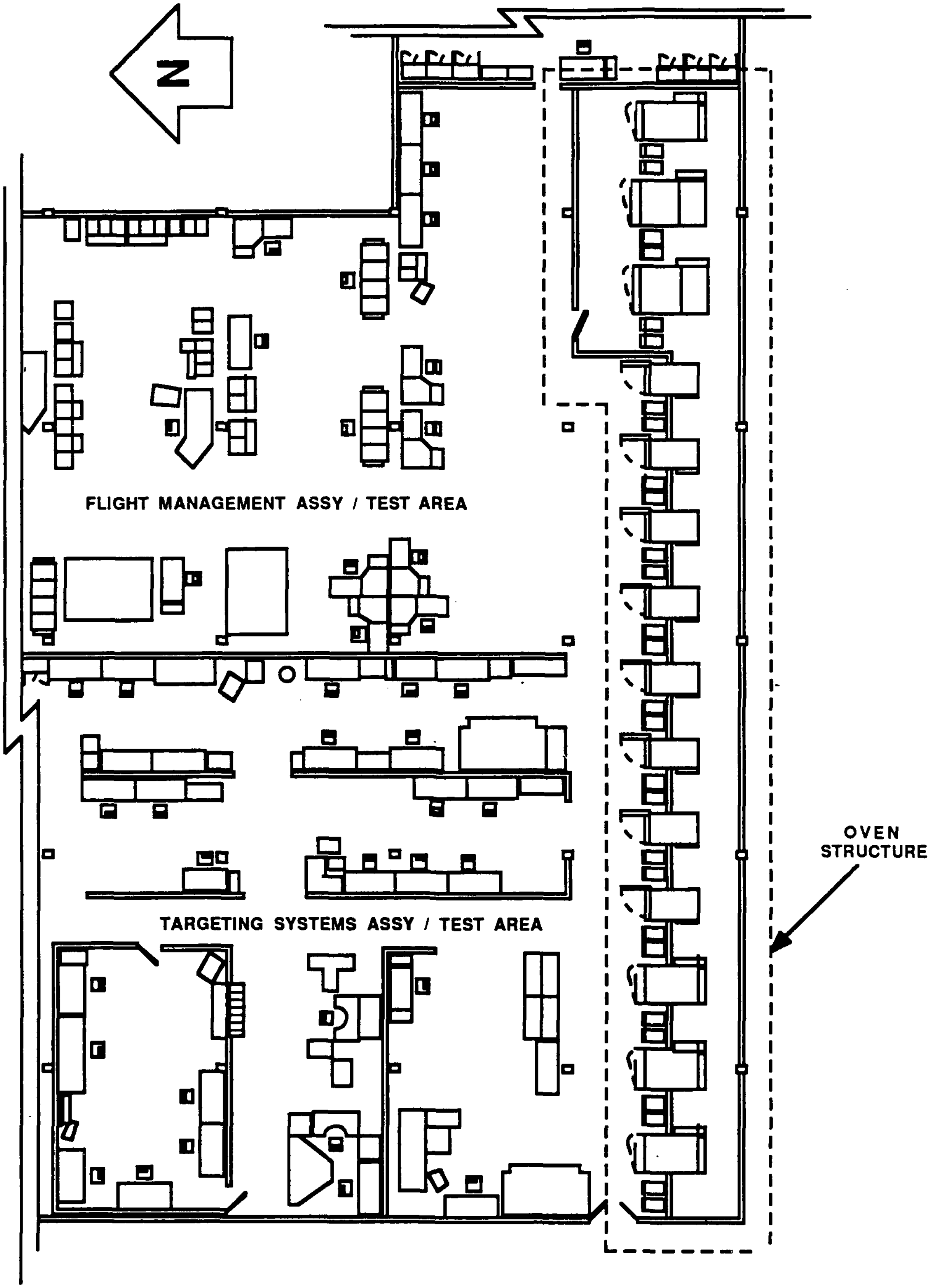


Figure 5.6.3.1-2 "To-Be" FM & TS Oven Isolation Structure

SECTION 6

PROJECT ASSUMPTIONS

ITM Project 80 has proceeded with the following assumptions as fundamental guidelines. Project implementation could be impacted and schedules affected if alternative approaches or significant deviations to plan are executed.

- Capital funds will be available for equipment purchases during fiscal year 1988.
- Sufficient manpower to implement proposed changes will be allocated to ITM Project 80.
- FM & TS Production Engineering will coordinate implementation efforts.
- Each unique workstation will be configured and pilot testing will be completed prior to commencement of full scale production. This activity will occur within the respective area utilizing production operators.
- Implementation will not be considered finalized until designated equipment is in place as depicted in the ITM Project 80 plan.
- As much as practical, software packages procured as part of the project implementation will be standard, off-the-shelf products so as to avoid on-going maintenance associated with customized packages.
- For the project duration, the Flight Management and Targeting Systems build schedules were tied to revenue growth within FM & TS.

SECTION 7

GROUP TECHNOLOGY CODING SYSTEM ANALYSIS

The term Group Technology has been alternately used to describe either of the following:

1) a process of codifying parts in a computer database in order to group similar parts or,

2) the organization of product families into cells in order to eliminate the duplication of resources.

The first definition of Group Technology was developed during the 1970's for the standardization of production materials and is used in a number of ways in the design and manufacture of a wide variety of products. The major impetus for this came through the use of more powerful and sophisticated computer systems and integrated CAD design software. This technique was not viewed as particularly critical to the development of the design and equipment requirements for ITM Project 80.

The second definition presented above is a more recent view of Group Technology. This method has been adapted from the Japanese and provides a more global view of integrating manufacturing processes and streamlining production operations.

The grouping of production operations was achieved by developing large scale matrices which correlated the Honeywell part number with the operations and the standard hours required to perform these operations. These correlation matrices provided important information for grouping similar processes at workstations, defining the equipment required at each specific type of workstation as well as the actual number of workstations required for each of these groupings of operations.

The steps for developing this matrix were:

1) All part numbers of assemblies and sub-assemblies were listed along the "y" axis of the matrix.

2) Production layouts provided the operations descriptions (which are in the process of standardization and codifying) for each operation for the production of a sub-assembly or assembly. These operations descriptions were listed along the "x" axis of the matrix.

3) At each intersection in the matrix of a part number and an operation description, the standard hours for an operation for that part number were entered.

4) After the data was entered into the matrix, each individual production operation was analyzed for grouping at a specific type of workstation dependent upon the processes performed.

5) Similar processes or processes requiring the same type of tooling and equipment were grouped together.

6) The matrix was then condensed to define a set number of types of workstations that could facilitate the grouped operations.

7) On separate versions of the matrix, production totals (box and spares counts) were entered for the years 1986 and 1987. These were then multiplied for each part number and each operation column was totaled.

8) These standards were then verified for 1986 using the Foreman's Cost Report (for total hours in each operational area) as a check against the completeness of the matrix.

9) Business volume projections were established for the operational area (card/device, targeting) and standard hours were projected for ten years using an established percentage growth for the FM & TS operations.

10) Actual hours for each type of workstation were established using cost variance ratios established by FM & TS Cost Accounting department.

11) Actual number of workstations was established by dividing actual hours per type of workstation by 1800 hours. The assumption of 1800 hours/year/employee allows for 80 hours vacation, 80 hours holiday, 120 hours for lost time (sick, jury, etc.).

12) This established the number and type of workstations required for all current programs for the next ten years and provides a methodology for establishing the number and type of workstations required as newer programs are phased in.

Once all of the workstations were designated using the procedures outlined above, the groupings of the workstations were laid out based upon the process flow to provide optimized routings for the majority (approximately 80%) of the product that will be built in the work area. In addition, the accessibility of resources was analyzed in relation to the work cell designs as well as the physical characteristics of the products assembled.

Following the development of the work cells, these were then laid out for optimum routing between each cell. Once the work area was designed, the material handling and storage requirements were developed to facilitate the process flow between cells.

SECTION 8

PRELIMINARY/FINAL DESIGN AND FINDINGS

The following section describes the process of preliminary findings and design iterations as well as the Final Design that will be in place as a direct result of ITM Project 80 and the final design findings that led up to it.

The primary emphasis of ITM Project 80 is on the improvement of material handling systems and equipment as well as the relayout of the FM & TS card/device and targeting areas. Other areas described in this section include:

- Production/Process Flow
- Material Flow
- Information Flow

8.1 "To-Be" Operations Overview

The approach to the development of the final design of the "To-Be" factory has been described in Section 3 "Technical Approach" of this document. In addition, in describing the "To-Be" factory in Section 5, the refined methods for arriving at the "To-Be" design are included as part of the justification and description of that design.

8.2 FM & TS Area Floor Plans

The preliminary floor plan design began with an evaluation of three factors:

- Product volume
- Processes employed
- Product flows

Product Volume

The product volumes were derived and matrix data developed from 1986 card/device and targeting area completion records. Where applicable, model (or program) identification was maintained. It was also necessary to validate the matrix data with product quantities and standard-to-actual ratios. This effort would provide a benchmark for determining headcount by comparison of 1986 totals obtained from different sources. Additionally, marketing data provided a projection of future years' expectations and an estimate of space required to accommodate growth.

The aforementioned combination yielded a projected headcount figure over the project duration and identification of gross workstation space.

Processes Employed

The matrix (referred to above) also permitted a grouping of the same or similar operations. These were then reviewed to determine combinations of tools and/or skills which were capable of being combined.

As an example, the result in the targeting area was the establishment of process oriented stations, through which all unique assemblies and sub-assemblies pass, as dictated by the processing each requires. This permits the grouping of resources necessary to complete processing of a particular sub-assembly.

In the card/device area, operations were clustered by product/program. This approach concentrates manpower resources on specific products to assure technical expertise and a higher level of quality.

Product Flows

A major goal of ITM Project 80 was the consolidation of areas. In the card/device and targeting areas, significant unnecessary travel is dictated by location of areas within the St. Louis Park facility as well as the internal layout of those areas. The preliminary design addressed those flows and that resulted in significantly altered floor layouts.

Design Formulation

The combination of the previously mentioned volume, processes, and flows resulted in a preliminary plan for the targeting area which essentially had a linear flow. Material entered and was successively processed in various stations in a "straight-line" fashion. This resulted in an average flow distance reduction of more than 20% over the "As-Is" configuration. The design was also reviewed with alternative workstation arrangements to provide personnel with optimized work surface design.

The card/device flow was centered around product/program testing and burn-in, however, substantial efficiencies were obtained by the integration of all product associated operations into one area. Most significant is the ability to direct all card/device activities in one place and optimize personnel resources while minimizing time lost traveling from area to area. Considerable savings in flow distance, requiring the utilization of stores personnel, was achieved by integration of the remote card/device/FAST area with the main card/device area.

8.2.1 Card/Device Area Floor Plan

The card/device area floor plan development required that production layouts for all products currently built within the area in 1986 and projected production for 1987 be analyzed. These layouts provided the initial data for establishing standard hours per operation per part number. This data was then used to develop a group technology analysis matrix. Data regarding operations descriptions was defined along the x-axis, part numbers of assemblies and sub-assemblies were listed along the y-axis, and standard hours were entered at the appropriate part number/operation intersection.

Production totals were entered for each of the part numbers in the matrix for 1986 production. A second matrix was used to enter projected production totals for 1987. A calculation was then made by multiplying the production totals by the operation standard hours for each of the part numbers which resulted in a second matrix physically as large as the first one but now representing total standard hours for each unique operation per part number.

Production layouts were subsequently referenced to assist in grouping operations that were or could be performed at a specific type of workstation. The groupings were then reviewed by personnel within the card/device group for accuracy. The matrices were then consolidated into seven major categories, which were:

- Card Test
- Card Coat
- Card Assembly
- Device Assembly
- Device Test
- Machine Group
- Sub-Assembly

The next consolidation of the matrix involved grouping all of the part numbers into their respective programs. Four major program areas were included in the analysis.

The numbers calculated for the 1986 consolidated matrix were then verified using the Foreman's Cost Report which lists the total standard hours expended in the card/device area.

Business volume projections were then established for the card/device area in conjunction with Honeywell's Costing and Forecasting groups. These projections were then analyzed to determine the percentage growth for Flight Management. This percentage growth was then applied to the figures calculated as the 1986 baseline standard hours to determine the standard hours required for production over a ten year period utilizing existing processes, etc.

Actual Hours figures were then established using cost variance ratios developed from the 1986 Foreman's Cost Control Summary.

The actual number of each type of workstation was established by dividing actual hours per type of workstation by 1800 hours. The assumption of 1800 hours per year allows for 80 hours vacation, 80 hours holiday, 120 hours for lost time (sick, jury, etc.).

After the initial effort to establish the number of workstations required and the characterization of the operations to be performed at the workstations, a number of assumptions and criteria were established and weighted as to importance for developing the card/device area floor plan with respect to work bench surfaces and test units. These included:

1) The assumption that the work area would be designed to accommodate all of the work projected during a one shift operation.

2) Specific areas would be provided to accommodate work load peaks as well as expansion for new programs and processes.

3) Floor space utilization would be minimized so that the footprint of the overall card/device area would be flexible enough for an implementation in a joint area defined to house both card/device and targeting operations.

4) Work cells or clusters would be developed to provide a more organized area and more direct process flow. The characteristics of these would be that:

    a) Cells were developed for specific products.

    b) Activities would be clustered to provide advantages of group technology related to similar parts and operations (e.g., card test, FAST line, environmental chambers, etc.).

5) Standardized modular work benches would be defined to increase the flexibility of rearranging operations.

6) Cellular arrangements would be developed taking into account the latest developments in electronics manufacturing ergonomic studies while providing economical utilities (electrical, air, vacuum) installation.

7) Areas would be designed which provided for the ability to easily monitor all of the operations in the card/device work center.

After the development of the assumptions and criteria, detailed production flows were analyzed and used as input to the overall card/device

area layout. This analysis focused on the card/device area production rates (which was described utilizing pareto diagrams) that represented the highest volume programs so that transport savings would be maximized. This allowed optimization of all work bench surfaces plus additional equipment (test stations, etc.). The assumptions and criteria developed as a result of the production flow analysis included:

1) The placement of the card/device area near an entrance way for ease of accessibility to outside organizations that provide services or raw materials.

2) Integral operations would be located in a defined cell on a product-by-product basis.

3) The area would be designed to provide flexibility for the inclusion of additional programs.

4) Cells and other equipment were located to minimize "backtracking" or counterflow in the production process.

5) The concentration of the overall work area provided that even though flow distances were minimized, a sufficient area for expansion was provided to accommodate a three to five year time span.

Storage and material handling equipment requirements were developed to meet the needs of production for the next three to five years as well. Storage mechanisms (such as VS/RS) were based upon the volume of stored material and its proximity to the point of use. Briefly, one VS/RS was defined as adequate for card adapters and a second unit was dedicated to storage of area supplies and work-in-process. Unused VS/RS shelves will be reserved for work-in-process that cannot be completed due to material shortage. By concentrating material in the VS/RS units or directly at the point of use, the use of stationary racking can be minimized.

Movable cart storage was determined to be the most effective means of transporting work-in-process and aiding in the limitation of work-in-process storage. This was primarily due to the low volume of production in the card/device area and the relatively small area footprint occupied by this area.

Possible locations for the placement of the card/device area were then reviewed and evaluated for optimum placement of that activity within the total FM & TS production operation. Initially (as shown in Figure 8.2.1-1) it was determined to group the card/device and targeting areas with the chassis assembly area to facilitate a continuous production flow. One of the card/device area specific designs developed at this time is presented in Figure 8.2.1-2. As can be seen, while Automatic Test Equipment (ATE) is located in a concentrated area, the rework and support activities are not clustered to provide product/program grouping.

Version 1

1) Locates Ovens in Common Structure Against Outside Wall.

2) Locate Chassis & Wire Wrap near FM & TS Device assembly areas to facillitate production flow.

3) Locates FAST Line Between Targeting and Card/Device for Convenient Access to Major Areas Served.

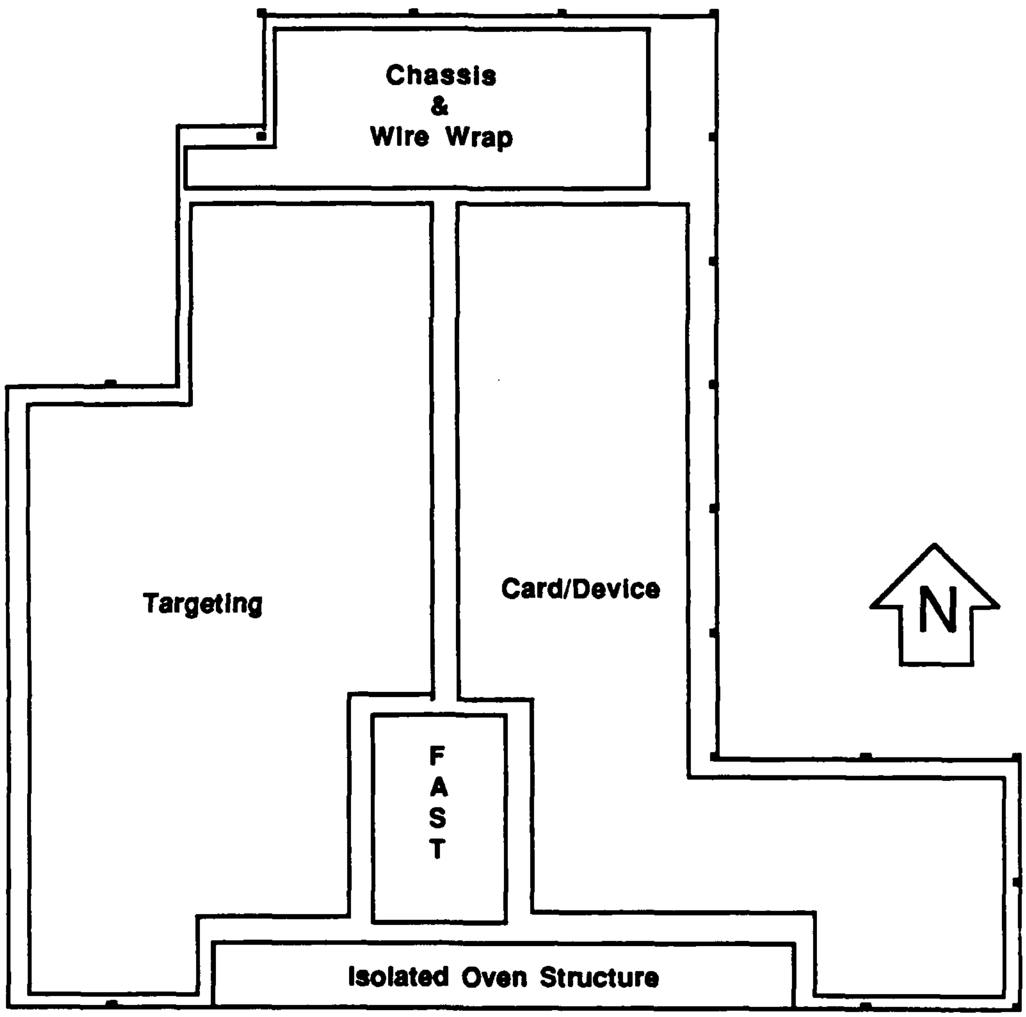


Figure 8.2.1-1 Future FM&TS - Initial Area Layout

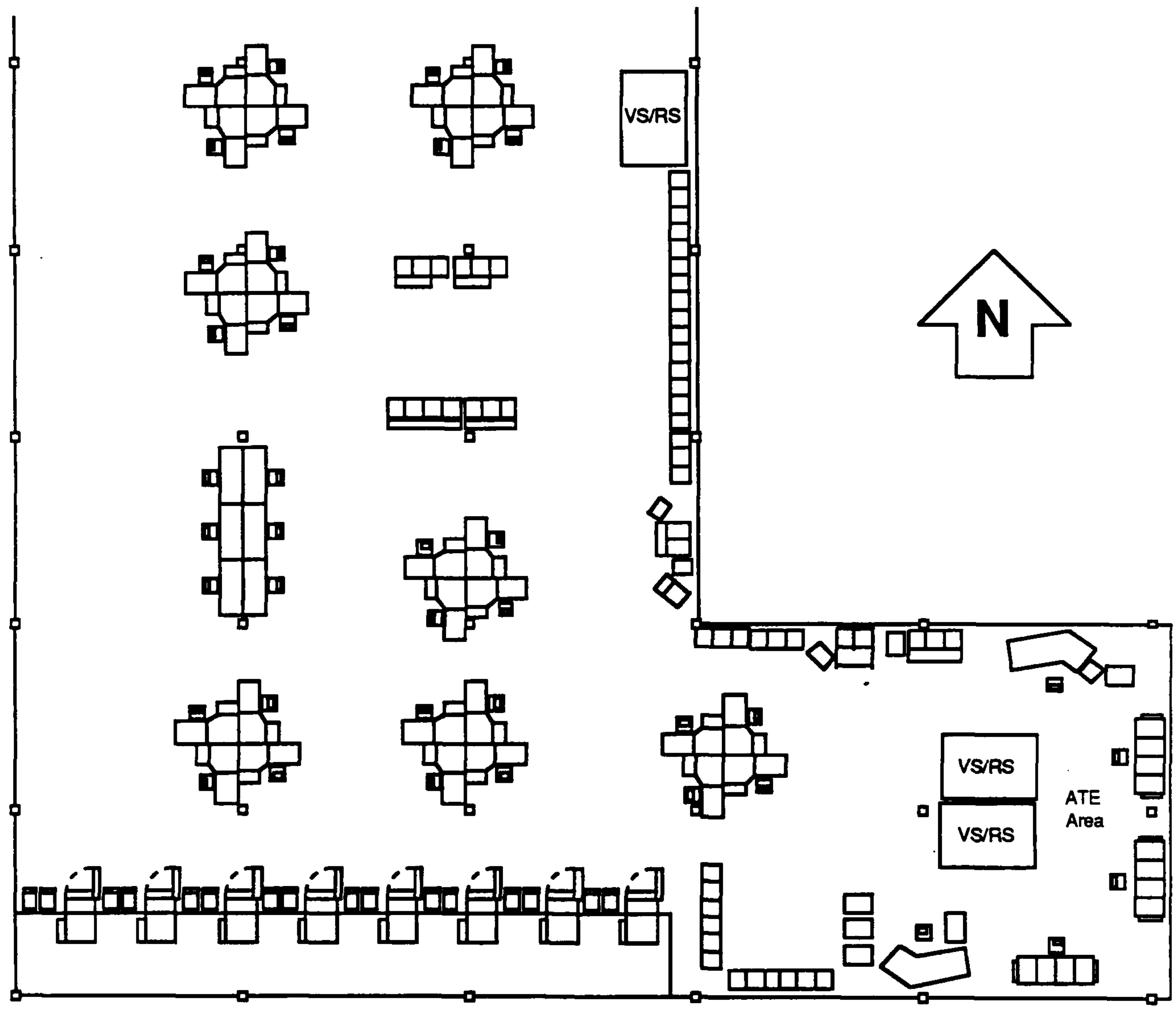


Figure 8.2.1-2 Card/Device Initial Area Layout

Additionally, the requirement that ATE Central be located near the main FM & TS Production area and the need to integrate another program (DEPRT - which was transferred from the Commercial Avionics Division) into the FM & TS area would not allow the placement of the chassis area as shown in Figure 8.2.1-1.

The resulting floor plan for the card/device area is presented in Figure 8.2.1-3 and can be characterized as providing the following features:

1) Wide aisles have been included to facilitate the ease of work flow.

2) The area has been organized into major program cells.

3) Printed Circuit Card testing has been clustered with a centralized adapter storage.

4) Storage of work-in-process and supplies is consolidated in a single VS/RS unit.

5) An area has been provided for a new tester and related support services.

6) Spare work bench surfaces are distributed to allow for work load peaks and new product development areas.

7) The card/device area has been located near an aisle to provide ready access for outside work delivery as the need arises.

8) Burn-In ovens have been grouped in a common isolated structure to eliminate environmental impacts (vibration, noise, heat).

9) All FM & TS ovens are located in one area for ease of service and to provide free access for both card/device and targeting operations. Specialized utilities (chilled water, power) are concentrated and isolated in a single structure.

10) The FAST line is conveniently located to support card/device activities.

11) In general, large cells and oversize aisleways allow addition of equipment or programs without crowding. The area has an expansion capacity of over one-third to accommodate increased production and future programs.

The major factors emphasized in the proposed floor plan include a more "free-form" environment with wider spacing, work place arrangements that promote greater operator interface, and work and materials storage is provided in close proximity to their point of use.

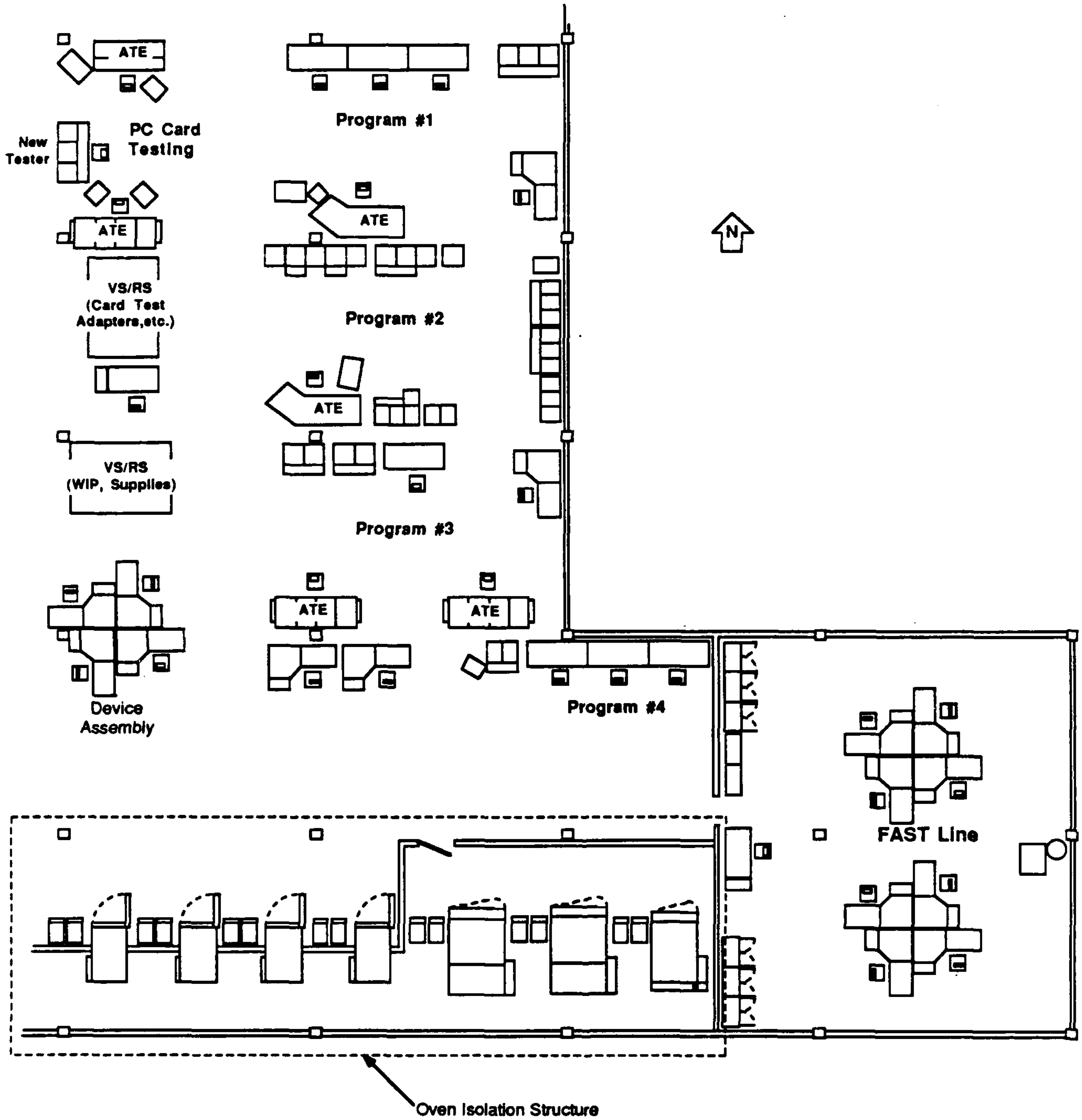


Figure 8.2.1-3 "To-Be" Card/Device Area Layout

The proposed floor plan provides for a significant reduction of flow distance within the area. While this reduction is not necessarily a significant cost driver for evaluating the improved card/device area arrangement, the non-quantifiable improvements in efficiency, reduction of material movement required by Group Leaders, elimination of product movement by stores personnel, and several other factors support this improved layout.

8.2.2 Targeting Area Floor Plan

The targeting area floor plan development required that production layouts for all products currently built within the area in 1986 and projected production for 1987 be analyzed. These layouts provided the initial data for grouping operations that were or could be performed at a specific type of workstation. In addition, because of the relatively "new" status of the targeting program, the main relayout task was not focused on the grouping of work cells, as these had previously been well defined due to the specific nature of the processes involved in manufacturing the product. Rather, the more important task was the "straightening out" of the physical area to facilitate an optimized production flow.

The operations groupings were reviewed by personnel within the targeting group for accuracy. These operations were then consolidated into five major categories, which were:

- CRT Build
- Clean Room (BRU and SSU)
- HDU Build
- Helmet Integration
- IHU Cell
- PCB Testing Cell
- Card Cage Assembly
- Darkroom
- Sub-Assembly Build (including epoxy)

Projections were then analyzed to determine the percentage growth for Targeting Systems to determine workstation requirements. After the initial effort to establish the number of workstations required and the characterization of the operations to be performed at the workstations, a number of assumptions and criteria were established and weighted as to importance for developing the targeting area floor plan with respect to work bench surfaces. These included:

1) The assumption that the work area would be designed to accommodate all of the work projected during a one shift operation.

2) Specific areas would be provided to accommodate work load peaks as well as expansion for new prototypes and production.

3) Floor space utilization would be minimized so that the footprint of the overall targeting area would be flexible enough for an implementation in a joint area defined to house both targeting and card/device operations.

4) Work cells or clusters would be developed to provide a more organized area and more direct process flow.

5) Standardized modular work benches would be defined to increase the flexibility of rearranging operations.

6) Cellular arrangements would be developed taking into account the latest developments in electronics manufacturing ergonomic studies and accommodate economic utilities installation.

7) Areas would be designed which provided for the ability to easily monitor all of the operations in the targeting work center.

After the development of the assumptions and criteria, detailed production flows (summarized in Figure 8.2.2-1) were analyzed and used as input to the overall targeting area layout. The assumptions and criteria developed as a result of the production flow analysis included:

1) Centralization of assembly and testing operations.

2) Establishment of more efficiently laid out darkroom structures for CRT and other testing.

3) Product/process assembly paths which flow in and out of a central point.

4) Consolidation of the overall work area which, while minimizing flow distance, provides sufficient area for expansion in the following three to five year time span.

Storage and material handling equipment requirements were developed to meet the needs of production for the next three to five years as well. Storage mechanisms (such as VS/RS) were based upon the volume of stored material and its proximity to the point of use. Briefly, one VS/RS was defined as adequate for helmets and helmet-related work-in-process and a second unit was dedicated to storage of card test adapters and related work-in-process, such as completed cards.

Movable cart storage or carried totes were determined to be the most effective means of transporting work-in-process and limiting work-in-process storage. This was primarily due to the low volume of production in the targeting area and the relatively small footprint occupied by this area.

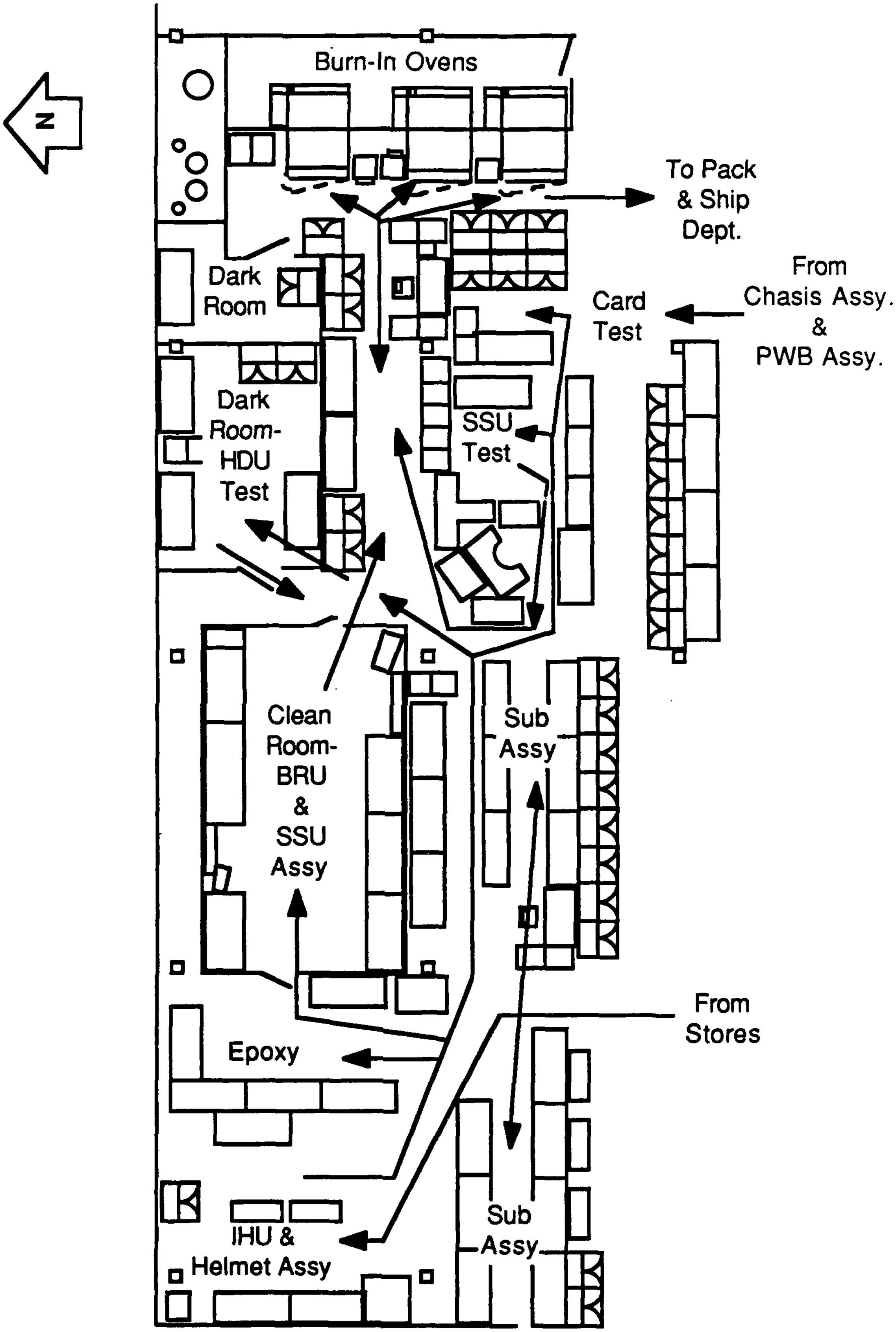


Figure 8.2.2-1 "As-Is" Targeting Production Flow

The resulting floor plan developed for the targeting area is presented in Figure 8.2.2-2 and can be characterized as providing the following features:

1) The targeting area is laid out to provide a relatively smooth flow from operation to operation.

2) The layout is configured with more than adequate aisle space so that variations in process requirements from assembly to assembly do not pose significant flow problems.

3) The clean room is enlarged four to five feet to improve flow and reduce crowding.

4) One VS/RS unit is positioned in close proximity to the helmet build area to store raw materials, work-in-process, and finished helmet assemblies.

5) The second VS/RS is located near the testing operations to provide supplies support, and adapter and work-in-process storage.

6) The epoxy/curing area is centralized for ease of access from assembly cells.

7) CRT sub-assembly and testing are arranged in close proximity.

8) Ovens have been grouped in a common isolated structure to eliminate environmental (vibration, noise, and heat) impacts.

9) All FM & TS ovens are located in one area for ease of service and to provide free access for both card/device and targeting operations. Specialized utilities (chilled water, power) are concentrated and isolated in a single structure.

10) Testing activities are centralized to reduce transport distance.

The major factors emphasized in the proposed floor plan include more consolidated operations, major improvements in work flow, work place arrangements that promote greater operator interface, and work and materials storage are provided in close proximity to their point of use.

The proposed floor plan does not provide for a significant reduction in flow distance. The major benefit of the relayout is in eliminating clutter, backtracking, and congestion. While this reduction is not necessarily a significant cost driver for evaluating the improved targeting area arrangement, the non-quantifiable improvements in efficiency and the reduction of material movement required by Group Leaders and stores personnel support this improved layout.

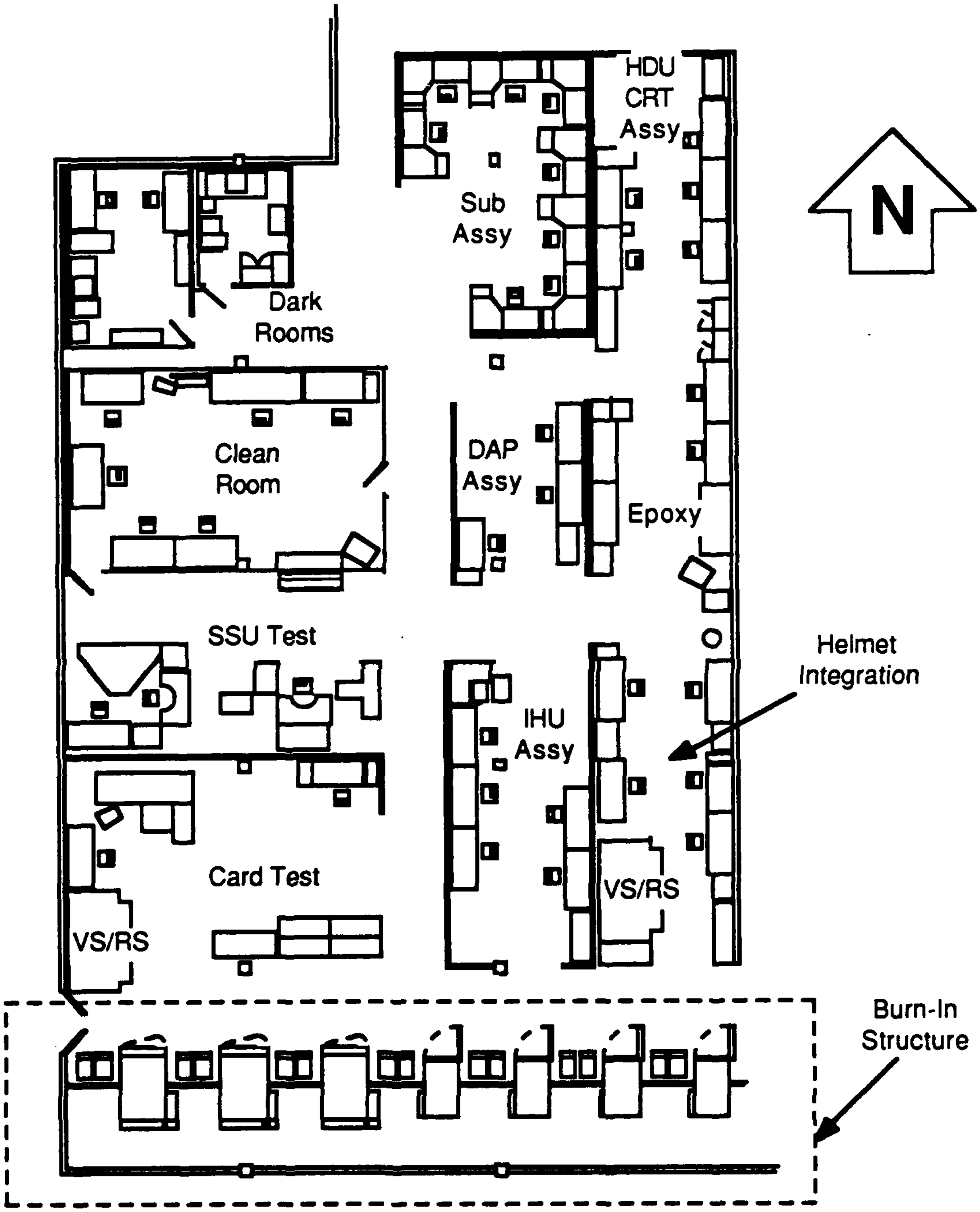


Figure 8.2.2-2 "To-Be" Targeting Area Layout

8.3 "To-Be" Production/Process Flow

The "To-Be" production/process flow is presented in the following sections. One of the major improvements in the optimized design of the production/process flow for each of the areas is the development of a straightforward production flow that is aligned with the process flow. Additionally, in the card/device area, the consolidation of the geographically distinct operations will result in significant production flow improvements.

8.3.1 Card/Device Area Production/Process Flow

As a result of the FM & TS relayout, activities related to card/device test and burn-in are consolidated in one area. This will allow testing of all devices to be performed in the same area as burn-in operations.

In the "As-Is" arrangement, area constraints require that some testing take place in a satellite area. This necessitates transporting units back and forth between areas for burn-in and repair/retest.

In the "To-Be" arrangement, external transport is eliminated. This minimizes delays in getting units into work and allows more uniform scheduling of labor resources. Additional area is provided as a "drop-off" point for material entering each cell.

Additionally, all card testing is consolidated to avoid the transport and scheduling delays associated with having the Fluke ATE in the Commercial Division card area. This has been resolved by proposing that FM & TS purchase a dedicated Fluke Automated Tester.

8.3.2 Targeting Area Production/Process Flow

As a result of the FM & TS relayout activities related to the targeting area, assembly and test are relocated to one area 95 percent larger than previously occupied. This permits each process to be located in a manner which enhances production flow.

All sub-assembly activities supporting major targeting assembly production are located in the production area, facilitating utilization of operator resources.

In addition to improving circulation throughout the targeting production area, additional space is provided in the "clean" room to reduce congestion and improve flow in that area.

8.4 "To-Be" Material Flow

The improvements in the "To-Be" material flow are presented in the following paragraphs. In general, a number of characteristics can be stated regarding the improvements in both the card/device and targeting areas. The most important improvements in the material handling for both of the areas involves the methods and equipment used for material and fixturing storage.

8.4.1 "To-Be" Targeting Area Material Flow

The targeting area material flow will be significantly improved through the implementation of two major types of material handling and storage devices. These are:

- Vertical Storage and Retrieval Systems (VS/RS)
- Dedicated Material Handling Carts

This equipment is described in detail in the following subsections.

8.4.1.1 Vertical Storage and Retrieval Systems (VS/RS)

In the current targeting area configuration, over 1300 cubic feet is devoted to storage of all types, including helmets, supplies, queued material, work-in-process, repair parts, etc. In gross numbers, over a third of material currently stored is helmets and helmet-related work-in-process due to the bulky nature of the part itself.

In the "To-Be" targeting area operations, a majority of all of the material in these work areas will be stored in Vertical Storage and Retrieval Systems (VS/RS). VS/RS units are automated, micro-processor based storage and retrieval systems which occupy small footprints of space. Items are stored in pans which travel following a vertical enclosed loop track. Pans are brought to work counter height via the shortest route. An operator does not have to bend, search, or grow fatigued looking for an item, therefore improving productivity.

These systems will reduce the floor space utilized for storage significantly and consolidate material into specific areas adjacent to the materials' points of use which reduces the material movement travel time. It will also assist group leaders and operators by significantly reducing the time associated with locating materials.

It is proposed that one VS/RS be oriented near the helmet assembly area. The second VS/RS will be utilized for the storage of card assemblies, card adapters, and other device-related work-in-process items.

Another significant improvement associated with the implementation of the VS/RS units is the addition of a purchased computer-driven material locating system for each of the VS/RS units in the areas. While many users require a simple "go to pan" operation, to take full advantage of these units, a storage and retrieval locating system is proposed. This will serve to eliminate excessive time required to search for the appropriate materials and more optimized utilization of the storage devices.

Figure 8.4.1.1-1 presents an elementary software diagram for a basic storage management system. This type of system consists of five major modules, which are described in the following paragraphs.

Storage Management Module

The Storage Management Module (SMM) should manage the Storage Database, Part Number Database, and Storage Arrangement Table. The SMM should create inventory records and provide keyed access to the Storage Database, Part Number Database, and the Storage Arrangement Table. The Storage Database should contain the following elements:

- Location (shelf number)
- Part Number (multiple part numbers may be stored on same shelf)

The Part Number Database should contain:

- Part number (either for a specific assembly or sub-assembly, fixturing, etc.)
- Location (for known stored parts or fixtures)
- Part number size attributes (for entered part numbers)

The Storage Arrangement Table should contain:

- Location
- Size attributes

System Interface Module

The System Interface Module (SIM) should be the operator interface module that services the PC keyboard and display. SIM should manage operator inquiry functions, file utilities, report generation selection, and access to system utilities. SIM should produce the following on-line query screens:

- Part number in location
- Size attributes of part number
- Size attributes of location
- Statistics summary

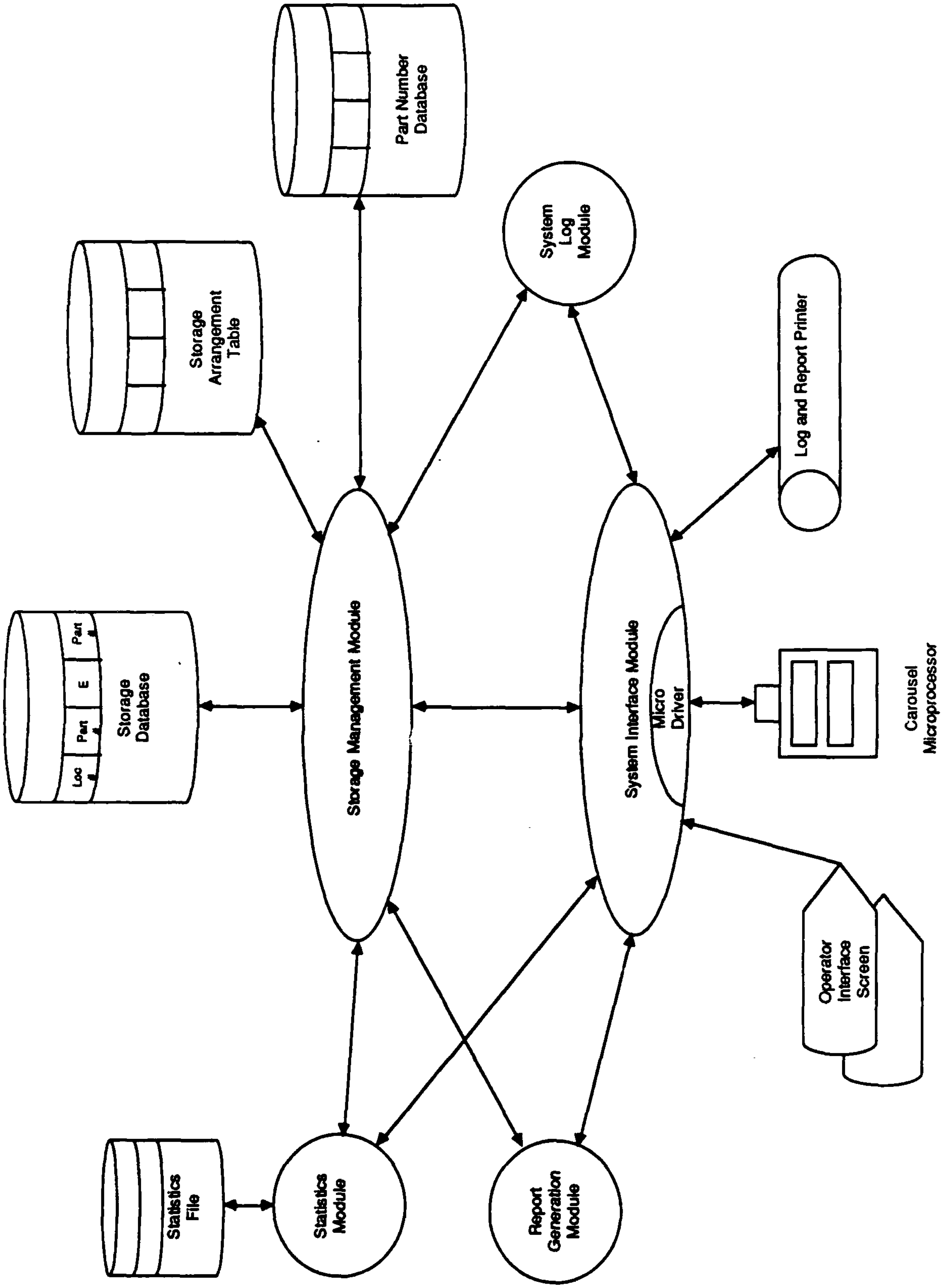


Figure 8.4.1.1-1 Storage Management System Elementary Software Diagram

System Log Module

The System Log Module (SLM) should maintain a disk file that records critical system activity and error conditions for later processing by the SIM report generation routines. All SLM entries should be time-stamped and identified by the originating module. Events logged by SLM should include:

- Putaway errors
- Part number location errors
- Operating system error codes returned to programs
- Disk faults

Statistics Module

The statistics module should keep track of performance information of the putaway system.

Report Generation Module

The Report Generation Module should be a collection of small report generating programs that produce management summary reports.

The implementation of this system as well as the implementation of the Factory Data Collection System and the HMS/BOS system should greatly improve the tracking of material and work-in-process in the targeting area.

8.4.1.2 Dedicated Material Handling Carts

In the proposed plan, material would be transported throughout the work area on carts purchased from available designs with a very limited number of shelves and closeable/lockable doors. The major premise behind this is to only have material on the shop floor that is being worked on and all other materials stored in a defined location. Since work-in-process storage could potentially occupy approximately 500 or more cubic feet in the Vertical Storage and Retrieval System, improved material handling disciplines must be established to avoid "hiding" excess material in a VS/RS.

The benefit of limiting work-in-process storage to carts (with work-in-process in the VS/RS stored due to lack of materials to complete the job or as completed sub-assemblies) is that what is actually "in-process" will be readily apparent. [The Japanese liken this method to that of draining a pond to make the bottom a smooth surface. As water is taken away, the largest rocks appear first. As each rock (or unnecessarily stored item) is removed, the pond is further drained until all of the rocks are removed.]

By not providing unlimited and hidden storage areas, problems related to timely delivery of kitted parts, etc. will surface and be more effectively dealt with.

8.4.2 "To-Be" Card/Device Area Material Flow

The card/device area material flow will be significantly improved through the implementation of Vertical Storage and Retrieval Systems. Currently, the storage of all materials in the card/device area is in a variety of cabinets distributed throughout operational areas. The greatest amount of cabinet space is assigned to store tested cards and card adapters. In other areas, there are 42 large cabinets and over 30 "under bench top" shelves used for storage. In total, there are 80 -individual storage locations totaling over 1300 cubic feet.

By establishing two VS/RS units, this storage space can be centralized for material presently spread around the areas. Furthermore, easier storage and retrieval will be made possible via the automatic locater system described in the previous "To-Be" targeting Area Material Flow section.

The VS/RS unit will increase floor space utilization by concentrating a greater amount of cubic storage in one area through the use of three additional feet of height. By bringing material to a usable height for placement/retrieval, spaces which are normally wasted in cabinets (near the floor or above an operator's head) are reclaimed for use. A ten foot high VS/RS can make available 350 cubic feet of storage in a space that tall cabinets can only provide 190 cubic feet, an increase of 84%. Additionally, travel distance with a VS/RS is cut to one-quarter to access the equivalent volume. The use of two VS/RS units in the card/device area reduces the cubic foot storage volume by approximately 550 cubic feet.

The proposed integrated and consolidated card/device area will contain two VS/RS units. These will serve the main activity areas of card test adapters and device sub-assembly work-in-process. This will provide supplies closely coupled to the point of use. Also, since card adapters are estimated to take up all of one VS/RS unit, the proximity of the other will permit any excess demand to be accommodated in the work-in-process VS/RS.

As an additional benefit in the future, the VS/RS equipment is capable of integration into the overall information management system.

8.5 "To-Be" Information Flow

The most significant improvements in the card/device and targeting areas information flow will be achieved with the introduction of the HMS/BOS system currently being modified for use at the St. Louis Park facility. While on a conceptual level this system performs all of the same processes as the GAPOS system, the increase in functionality is significant. Because the two systems are similar in the types of functions they will be performing and the final definition of

the system has yet to be implemented, the focus of this section will be primarily on the introduction of the Factory Data Collection system and the improvements outlined in this report that can be even further upgraded due to their selection for interfacing with a work center controller.

The Factory Data Collection (FDC) system has been developed as a means of automatically recording hours an employee expends on a specific operation/part number. This provides important information to FM & TS management both for accounting purposes as well as monitoring the percentage of completion of a specific part or unit being built. It is envisioned that in the future, the FDC system will be expanded to provide location tracking of work-in-process as well.

It is proposed that at some point in the future the Vertical Storage and Retrieval Locator System will be interface to HMS/BOS, either directly (which is not recommended) or through another system such as the Factory Data Collection System. This would provide a more integrated material tracking system.

One other program which is currently under evaluation for Honeywell's MAvD is the introduction of a "Factoryvision" system (ITM Project 32) which will present production layouts and other production related information to each of the operators on the shop floor. This type of system, interfaced with a work center controller would raise Honeywell's operations to the most advanced, state-of-the-art achievable with the computing technology available today.

8.6 "To-Be" Equipment

The following section describes the equipment proposed for implementation in the FM & TS card/device and targeting areas. This equipment significantly improves the operations in these areas and provides for the operations of these areas on a higher level of automation with, in some cases, the upward compatibility to an advanced work center controller being considered for future implementation.

8.6.1 Material Handling Equipment Improvements/Upgrades

There are two main material handling equipment improvements or upgrades that are presented in the "To-Be" operations in the card/device and targeting areas that affect the overall work area design. This equipment includes:

- Vertical Storage and Retrieval Units
- Material Handling Carts

8.6.2 Workstation Improvements/Upgrades

Considerable interest has been generated in the electronic manufacturing community over the past few years over improving productivity in the workplace. The FM & TS organization has been evaluating and incorporating some newer, modular workstations into its operations to improve productivity through better arrangement and efficiency at the work surface.

The Tech Mod project team has reviewed several styles of workstations in an effort to determine the most suitable configuration and arrangement which will enhance productivity. The team was assisted in this effort by the findings of the U. S. Navy Electronics Manufacturing Productivity Facility (EMPF) in their study of several types of workstations.

The EMPF, in a study that included both male and female subjects involved in electronic assembly activities, concluded that the most productive environment for workers occurs when the operator is placed in a modular work space with minimal opportunity for visual distraction. The study found that the *elimination of "eye contact" in the work environment contributed 22% to the* overall productivity of subjects involved in electronic assembly activities, thus allowing concentration on assigned tasks.

The Tech Mod team also reviewed various workstation configurations which could potentially take advantage of the EMPF study results. Two main arrangements were derived that allowed both efficient work flow and economical arrangement:

- Work Cells
- Bench Clusters

The work cell may consist of two or three benches arranged to provide a straight line flow as products are passed through a series of steps in the cell. This arrangement generally conserves floor space and provides linear external flow lines.

The second configuration is a four bench "cluster" which, while requiring external circulation to move work from station to station, benefits from requiring a singular utility drop thereby allowing economical installation and relocation. This arrangement allows what FM & TS Production management feels are beneficial operator groupings to accomplish similar or sequence related tasks. Utilizing this type of workstation grouping resulted in a reduction of thirty-four percent in flow distances for the card/device area.

The Tech Mod team also reviewed bench styles and construction details from several manufacturers. While most bench manufacturers employ components formed from cold-rolled steel tubing, some utilize aluminum alloy materials which are more than durable enough for the types of activities and weights encountered in electronic assembly, and which offer attractive cost savings in implementation.

8.6.3 "To-Be" Burn-In Operations

Burn-in will be comprised of a number of improvements including more environmentally isolated ovens which will provide consolidated access for servicing, a consolidated oven structure to contain heat and noise in a single structure, and individual oven isolation on the floor to reduce vibration dissemination as well as additional noise.

Additionally, the burn-in operations will benefit from the introduction of an oven monitoring network (part of ITM Project 82), which will record oven performance data automatically and provide a signal for out of tolerance conditions. This may be upgraded in the future to automatically control the ovens, also.

8.6.3.1 Oven Isolation Structure

Currently, the ovens in use in the FM & TS card/device and targeting operations are divided into several locations throughout the areas. In the "To-Be" operations, the ovens will be consolidated in one area along the south wall of the proposed site within the St. Louis Park facility. Figure 8.6.3.1-1 presents a conceptual view of the oven isolation structure and its location with respect to the two operations while Figure 8.6.3.1-2 presents a detailed depiction of the proposed oven isolation structure.

The installation of FM & TS ovens into one integrated structure provides several environmental benefits, including:

- Reduced operating noise
- Reduced vibration transmission
- Virtual elimination of heat gain in working area

The centralization of all of the ovens will also provide for the elimination of remote sites and the improved ability to load, monitor, and adjust the ovens.

The consolidated oven structure provides improved servicing and maintenance where work at the back of the ovens does not impair testing operations. Typically, as seen in the targeting area, the oven isolation approach creates a significantly improved work environment by reducing heat and machinery noise.

The addition of the separate mounting pad further reduces the transmission of vibration and allows these units to be located in close proximity to other testing activities.

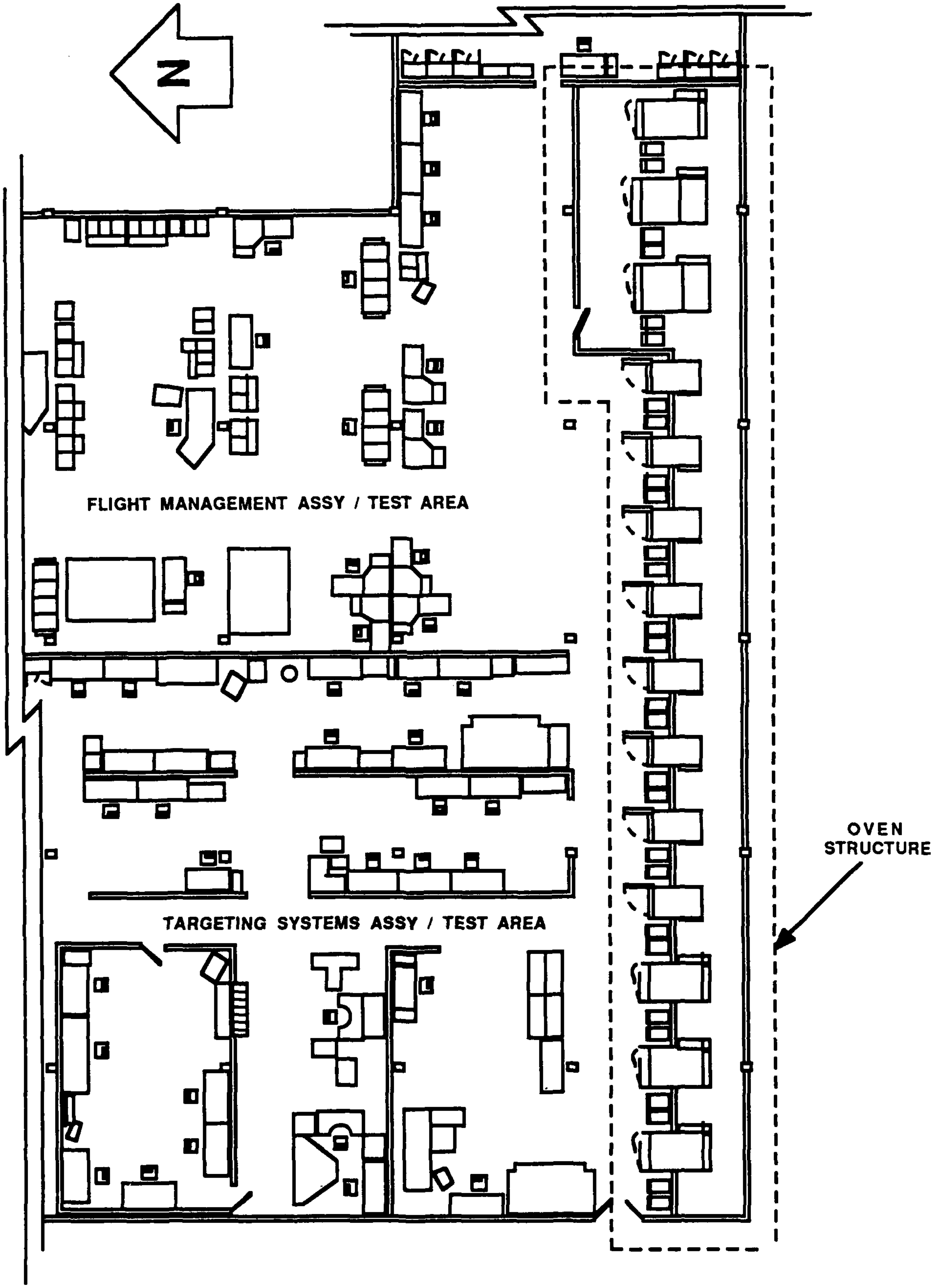
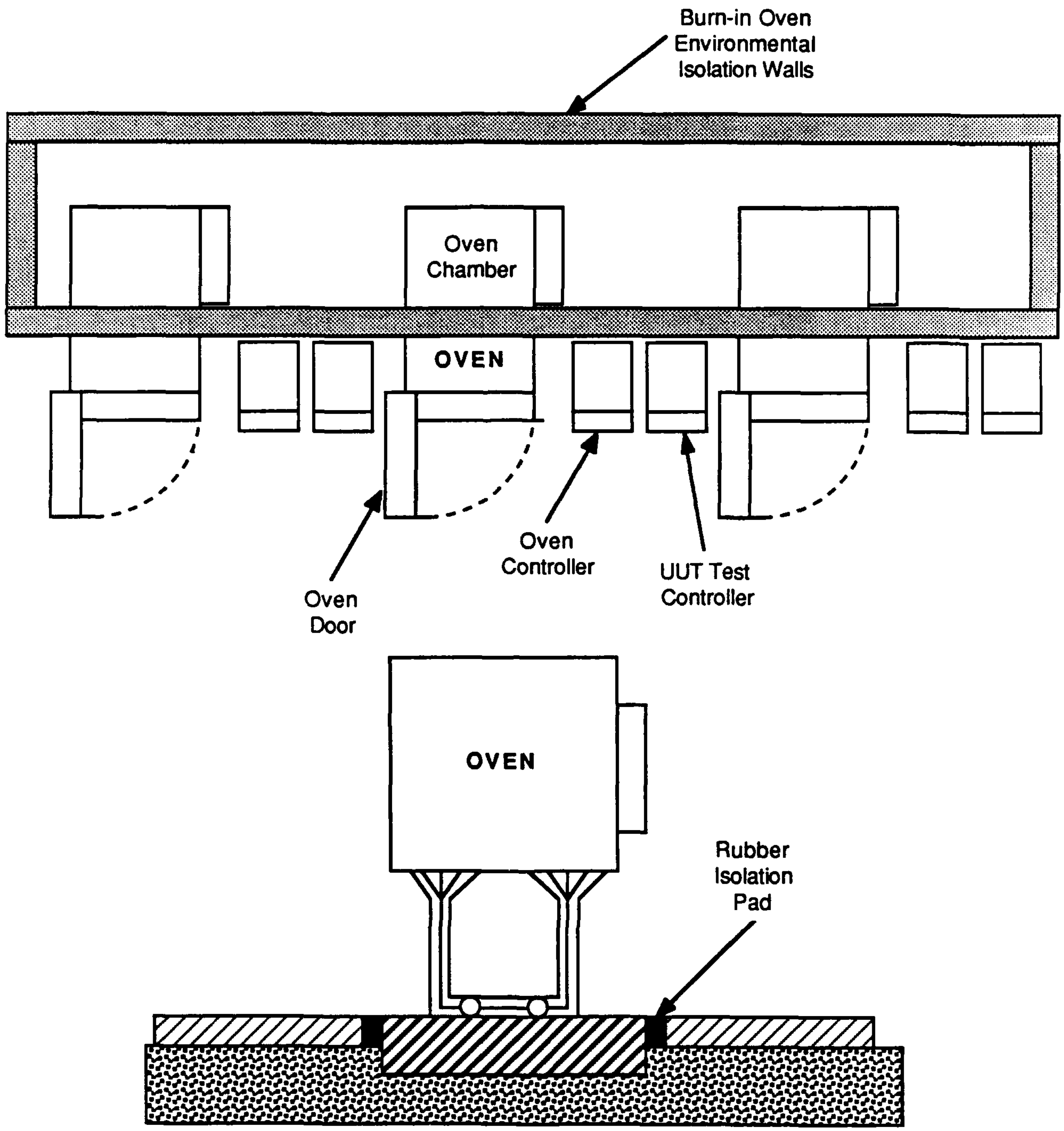


Figure 8.6.3.1-1 "To-Be" FM & TS Oven Isolation Structure



(Oven and Vibration Unit sit on extra thick concrete slab, isolated from Main Floor. Rubber is wedged in joint between "floating" slab and Main Floor)

Figure 8.6.3.1-2 Oven Isolation Structure

SECTION 9

SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS

The following sections present the detailed specifications that were developed as a result of the analysis and design performed for the two areas within Honeywell's FM & TS operations under ITM Project 80. The specifications have been developed for material handling and automated storage and retrieval equipment, including:

- Vertical Storage and Retrieval Units
- Computerized Putaway System
- Secure Material Handling Carts
- Ergonomic, Modular Work Benches

The specifications for this equipment are presented in the following paragraphs.

9.1 Vertical Storage and Retrieval System (VS/RS)

Dimensions:	7' wide x 10' long x 125" high
Counter:	40" high, static controlled
Shelves:	12 (min.)
Pan Pitch:	12"
Pan Depth	18"
Pan Load Capacity:	500 lbs.
Machine Capacity:	10,000 lbs.
Interface:	RS232C
Controls:	Supervisor's panel with keylock switch, rotary control and position display
Electrical:	230 VAC, 30 amp, single phase

9.2 Computerized Putaway System Specification

The following specification is provided primarily as a preliminary specification and may be modified to meet the specific needs of each individual VS/RS.

Hardware:

Personal Computer with internal hard disk
System Printer
System RS232C Interface Cable
Optional bar code reader

The system hardware interconnections should also allow for networking of PC's. This will allow for networking diskless PC's for complete carousel storage network.

Software:

The system software elementary diagram is pictorially described in Figure 9.2-1. Descriptions of each of the databases and modules are provided below.

1) Storage Management Module

The Storage Management Module (SMM) should manage the Storage Database, Part Number Database, and Storage Arrangement Table. The SMM should create inventory records and provide keyed access to the Storage Database, Part Number Database, and the Storage Arrangement Table.

The Storage Database should contain the following elements:

Location (shelf number)
Part Number (multiple part numbers may be stored on same shelf)

The Part Number Database should contain:

Part number (either for a specific assembly or sub-assembly, fixturing, cables, wire wrap plates, etc.)
Location (for known stored parts or fixtures)
Part number size attributes (for entered part numbers)

The Storage Arrangement Table should contain:

Location
Size attributes

2) System Interface Module

The System Interface Module (SIM) should be the operator interface module that services the PC keyboard and display. SIM should manage operator inquiry functions, file utilities, report generation selection, and access to system utilities. SIM should produce the following on-line query screens:

Part number in location
Size attributes of part number
Size attributes of location
Statistics summary

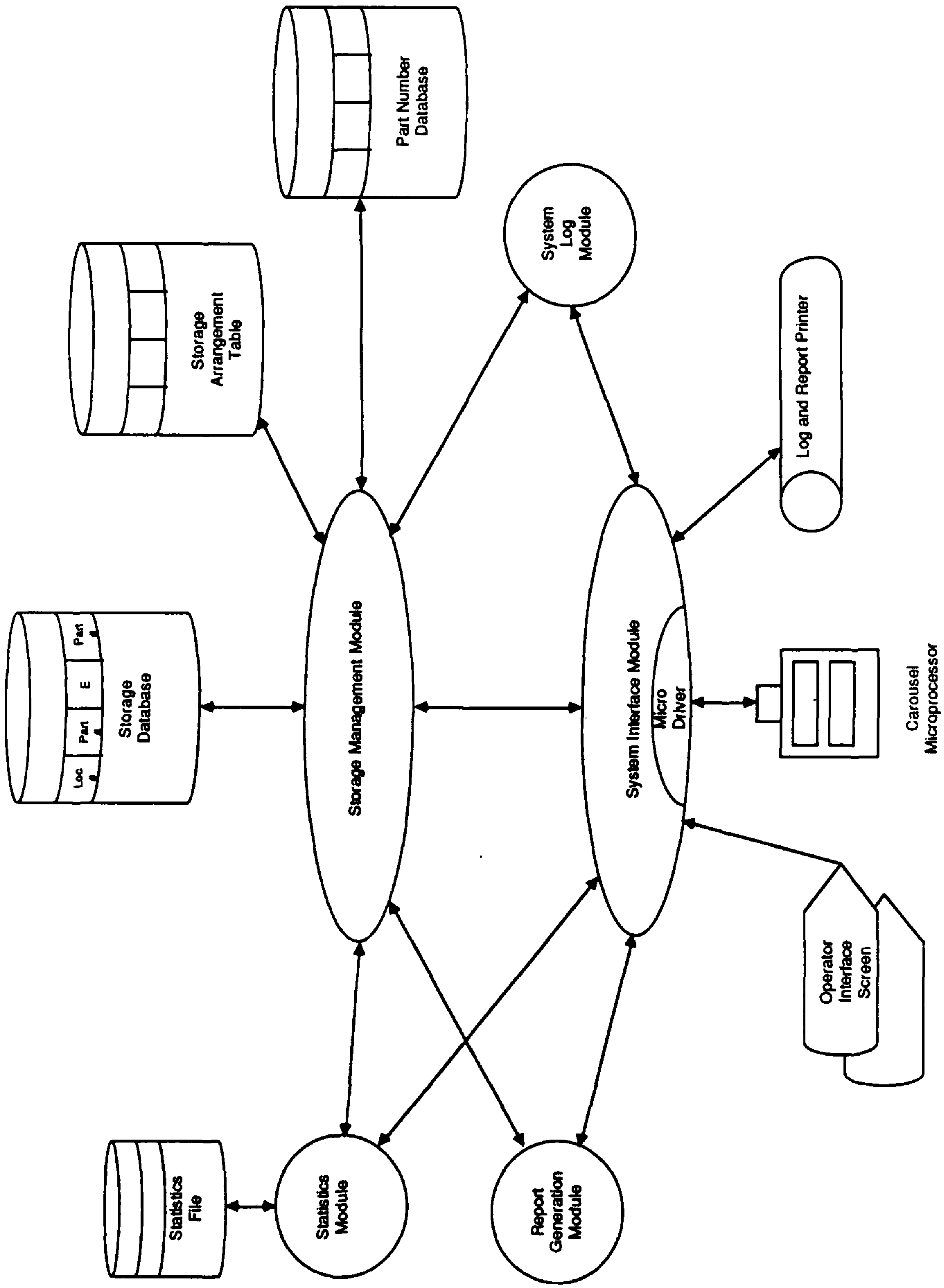


Figure 9.2-1 Storage Management System Elementary Software Diagram

3) System Log Module

The System Log Module (SLM) should maintain a disk file that records critical system activity and error conditions for later processing by the SIM report generation routines. All SLM entries should be time-stamped and identified by the originating module. Events logged by SLM should include:

Putaway errors
Part number location errors
Operating system error codes returned to programs
Disk faults

4) Statistics Module

The Statistics Module should keep track of performance information of the putaway system.

5) Report Generation Module

This module should be a collection of small report generating programs that produce management summary reports.

9.3 Modular Work Benches

Dimensions:	72" long x 36" wide x 30" high. (Optionally, height may be variable but this requirement limits number of vendors).
Work Surface:	ESD controlled with grounding attachments.
Shelf space:	Adjustable footrest shelf. (This may negate the requirement for a variable height work surface).
	Metal Instrument Shelf with back panel for mounting color coded cups for fastening hardware. 15" deep x 72" long x 24" high.
	Load balancing bar mounted minimum 36" above worksurface.
Drawer space:	Four drawered unit with master-keyed lock that locks all drawers.
Electrical Requirements:	Duplex outlets (110 AC) with raceway (either mounted along work surface or shelf).
Pneumatic Requirements:	Minimum 3/4" air line with two outlets and standard quick-disconnect couplings.
Lighting:	Dual fluorescent tubes in overhead canopy with diffuser.

9.4 Material Handling Carts

Dimensions:	36" long x 24" wide x 30" high
Shelves:	2 shelves with retainer lip, ESD mats, drag chain
Capacity:	100 lbs.
Casters:	3" - 4", rubber, brakes

SECTION 10

TOOLING

As a result of the nature of the design and development efforts (improved material handling), there is no unique tooling required for ITM Project 80.

SECTION 11

VENDOR/INDUSTRY ANALYSIS/FINDINGS

The project objectives which dictated realistic cost-payback relationships ultimately caused the review of a condensed group of material handling equipment vendors. Some equipment had been previously reviewed by FM & TS personnel so that the preliminary search and selection process was bypassed in the interest of eliminating duplication of effort.

Since the ITM Project 80 review of the FM & TS areas centered on material handling improvements and equipment upgrades, the selection process focused on the following areas:

- Vertical Storage and Retrieval Systems
- Dedicated Material Handling Carts
- Modular Workstations

Vertical Storage and Retrieval Systems

Several established vendors were contacted and reviewed for equipment suitability. Principal among these were White, J. Webb, and Kardex. The FM & TS organization has had previous experience with the VS/RS equipment manufactured by Kardex, and has found the capacity and service level satisfactory.

A primary requirement in the card/device area was the volumetric capacity to store nearly 200 card adapters and device work-in-process. Both Kardex and White had units with capabilities in this area.

The targeting area requires a unit similar to the one employed in the card and device area for storing helmets and device related materials along with station ATE card adapters.

All manufacturers were surveyed for the ability to provide standardized software systems to automate parts picking and putaway as well as storage space optimization. The desire to avoid "customized" control software was communicated to vendors quoting on FM & TS requirements primarily to avoid continued maintenance of a non-standard package.

The need for a more optimized storage system in the targeting area was identified vary early in the Phase 1 activity of the ITM program. Therefore, Production Engineering began an immediate search for a possible vendor. The equipment which was determined to be best suited for the application was the Kardex Industriever 6000 units. Two units intended specifically for use in the targeting area were ordered in February, 1987 and installed in April, 1987. Since Vendor pricing was reasonably competitive for this type of equipment, in the interest of inter-department uniformity, it is intended that Kardex units will be

purchased for the card/device area and that the computerized putaway system also be purchased from the same vendor.

Dedicated Material Handling Carts

Of all equipment specified for FM & TS, carts are possibly the most generic. Numerous vendors provide a suitable mobile unit. Capacities appropriate to the task of moving work around the area are manufactured by such companies as Metropolitan Wire Goods, Hodges, Gamco Industries, and several others.

Specifications generally cover wheel types, construction, and maximum capacities expected. A review of work flowing through the area indicates that the maximum weight of transported parts, assemblies, or kits falls in the range of 50 to 75 pounds, thus allowing carts of a wide range of structural types to be used.

It is anticipated that FM & TS operations management will review the outlined requirements and match that with a unit generally used in the area at present.

Workstations

Known vendors such as Herman Miller, Straether, Advance, Ergotech, etc. provide a wide range of competitively priced equipment. Some vendors have unique features, which in specialized applications might dictate selection, but the stations proposed for Project 80 are readily available in a configuration meeting the current area specifications. Since a few workstations have been purchased within the past year (not as a part of this project) from Herman Miller to be used within FM & TS, it was decided to specify Herman Miller equipment for continuity of style unless a strong case can be made for a special application prior to implementation. As a result, the average cost of the previously purchased stations was used for computation of factory costs.

SECTION 12

EQUIPMENT/MACHINERY ALTERNATIVES

Most of the equipment alternatives in ITM Project 80 are vendor-dependent rather than actual alternative technologies. The following paragraphs describe the alternatives to the equipments selected for ITM Project 80 in the event that the primary choice becomes unavailable.

Vertical Storage and Retrieval Systems

If the specified Kardex VS/RS units become unavailable several suitable alternatives exist. The primary alternative is a Model TB-1261 from White Storage & Retrieval Systems. The cost of the alternative hardware is comparable to the Kardex units, however the software is somewhat higher priced (approximately $15,000 more).

Dedicated Material Handling Carts

Of all equipment specified for the area, carts are possibly the most generic. Since the initial choice of vendor will depend upon the preferences of operations management to match units generally used in the area at present and numerous vendors provide a suitable mobile unit, making use of one or more of the alternate vendors would have little or no impact on the project implementation.

Workstations

The workstation vendor chosen (Herman Miller) is one of many which meet the requirements. There are several vendors whose equipment is comparably priced. Therefore, making use of one or more of the alternate vendors would have little or no impact on the project implementation.

SECTION 13

MIS REQUIREMENTS/IMPROVEMENTS

The most significant improvements in the FM & TS Card and Device Testing areas in respect to the Honeywell MIS department will be achieved with the introduction of the HMS/BOS system currently being modified for use at the St. Louis Park facility. HMS is a modular system comprised of the following modules:

- Master Production Scheduling (MPS)
- Inventory Records Management (IRM)
- Manufacturing Data Control (MDC)
- Material Requirements Planning (MRP)
- Capacity Requirements Planning (CRP)
- Purchase Material Control (PMC)
- Production Cost Accounting (PCA)

In addition to HMS, Honeywell is also implementing a process layout system which includes the Process Management System (PMS) and the Factory Data Collection (FDC) System.

The Factory Data Collection (FDC) system has been developed as a means of automatically recording hours an employee expends on a specific operation/part number. This provides important information to FM & TS management both for accounting purposes as well as monitoring the percentage of completion of a specific part being built. It is envisioned that in the future, the FDC system will be expanded to provide input to a system for location tracking of work in process as well.

Honeywell is also developing the specifications for a Work Center Manager System (WCM). While these specifications are still in the development phase, the improvements described in this document take into account the eventual implementation of these efforts and have been designed for future interface to a Work Center Manager System. The following paragraphs describe the basic functionality required of the Work Center Manager System.

A Work Center Manager System is typically a major piece of a hierarchically structured computerized factory control system. Residing at a higher hierarchical level than the WCM are the corporate systems and the MRP and MRP II systems such as HMS/BOS. Because MRP II systems are batch processing operations, the Work Center Manager has been assigned the responsibilities of direct, real time control of the factory floor. In this role, the system is responsible for short term, global scheduling tasks (during the operating day) and coordinating the inter-cell operations (such as material handling "hand-offs") that reside below it in the controls hierarchy.

It is also envisioned that the Work Center Manager will distribute graphics and textual process data to workstations and will maintain a process

data library which will be accessed by various pieces of the process control hierarchy (such as PLC's and other automated equipment).

It is envisioned that at some point in the future the Vertical Storage and Retrieval Putaway or Locator System will be interfaced to HMS/BOS, either directly or through another system such as the Factory Data Collection System to provide a more integrated material tracking system. It is not recommended that the Locator or Putaway System be interfaced directly to HMS/BOS due to the nature of a hierarchically controlled manufacturing operation. Systems such as HMS are typically batch-oriented systems and do not allow for the processing of real-time, lower level activities such as material/location tracking. It is therefore recommended that the Locator or Putaway System be interfaced through the Factory Data Collection System or the Work Center Manager.

One other program which is currently under evaluation for Honeywell's MAvD in conjunction with the Work Center Manager System is the introduction of ITM Project 32, which will present production layouts and other production related information to each of the operators on the shop floor. This type of system, interfaced with the Work Center Manager System would raise Honeywell's operations to the most advanced, state-of-the-art achievable with the computing technology available today.

SECTION 14

COST BENEFIT ANALYSIS AND PROCEDURE

In analyzing ITM Project 80, attention was focused on the methods and processes utilized in the FM & TS Card and Device Testing areas. Activities reviewed in these areas included material transport, workstation set-up, inter-area production flow, and personnel effectiveness.

In the initial stages of the project, several areas were identified as cost drivers and reviewed for possible savings using the methodology shown in the process diagram of Figure 14.0-1. This also required the identification of productivity and quality factors as a means of evaluating the cost drivers.

14.1 Productivity and Quality Factors

The productivity and quality factors that exhibited the greatest potential for benefit were:

- Labor Hours Devoted to Moving Material
- Operator Productivity (Standard/Actual Hours)
- Group Leader Time Expenditures
- Production Control Time Expenditures

Areas identified from the contract ledger data and foreman's cost control reports which did not result in significant benefit were:

- Scrap
- Rework

The relatively low annual volumes in ITM Project 80 resulted in virtually no scrap. This is primarily because the effect of any scrap action would be the loss of a device or card and subsequent schedule impact. Essentially, most problems (with the exception of physical damage and inaccessible defects) are resolved through corrective rework, thus avoiding disposing of a part or assembly.

Rework, on the other hand, is a major component of hours expended in the area. It is significant, however, that nearly all rework is outside operator control because it consists of hours applied as a result of E.O. incorporation or failure resolution in device testing and burn-in.

The following paragraphs describe the analytical basis for determining the benefit derived as a result if ITM Project 80 proposals.

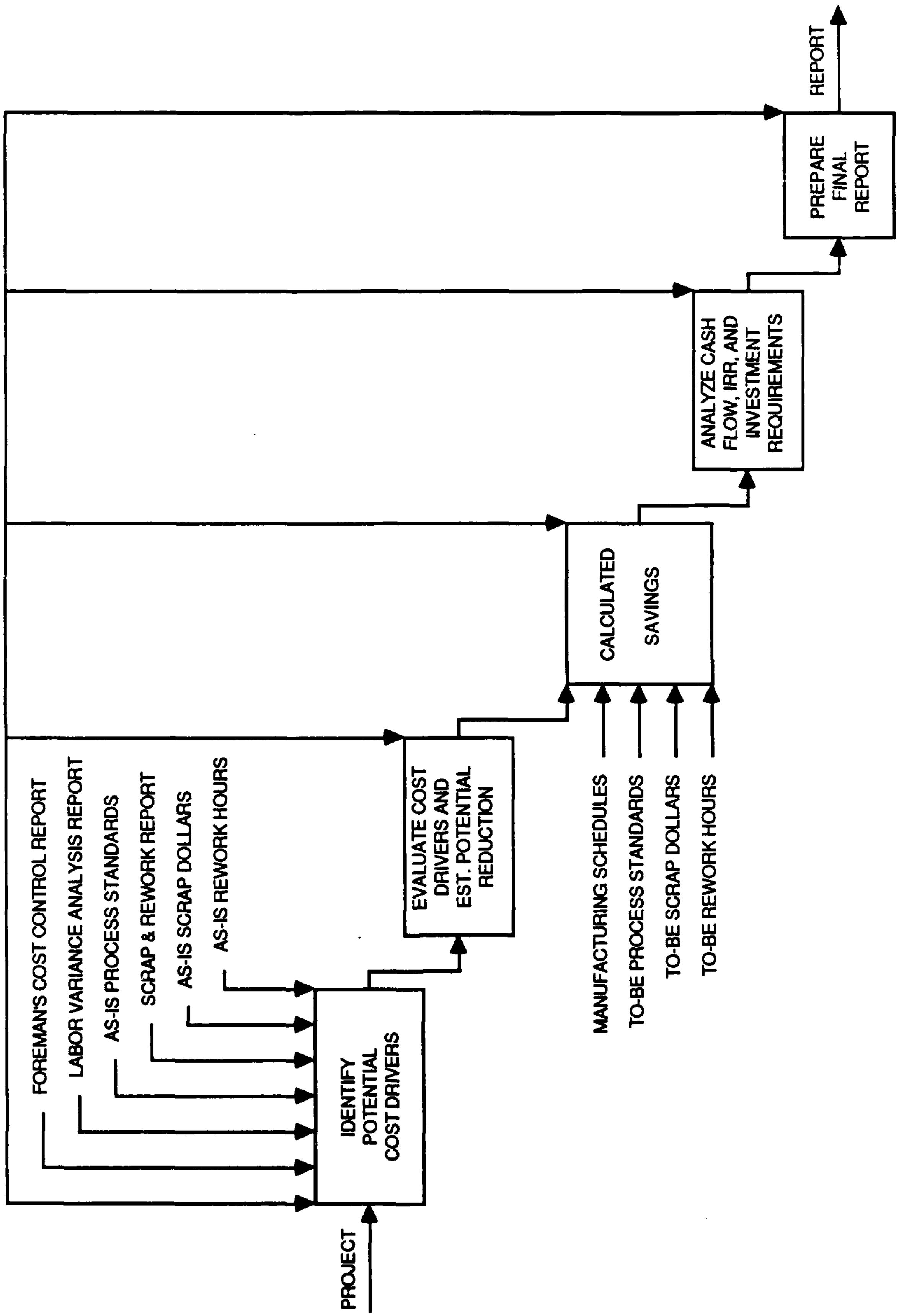


Figure 14.0-1 Cost Benefit Analysis Methodology

Standard Hours

Product standard hours were derived from internal Honeywell documentation and extended for 1986 production volumes to establish "As-Is" conditions. These totals were compared to those logged in the Foreman's Cost Control report for 1986 as a validation measure.

Specific operation surveys were performed by Industrial Engineering to form a baseline for "To-Be" operations in group leader and production control activities. Estimates of most "To-Be" operational standards were derived from study data gathered by the project team.

Evaluation of savings utilizing modular workstations was supported by data obtained in a study performed by the U.S. Navy Electronic Manufacturing Production Facility (EMPF), China Lake, CA. and generally substantiated by productivity increases experienced in the electronics industry.

Actual Hours

In determining savings for the card and device testing areas, actual operating ratios derived from Foreman's Cost Control reports were utilized. All standard hours were "normalized" to actual hours to perform "As-Is" versus "To-Be" comparisons on an area-by-area basis. This method is then able to accommodate the operational factors not normally included in standards.

Assumptions

All calculations are tabulated for ten yearly periods by quarter, beginning with the implementation point. Generally, implementation commences during 1988.

Production rate increase/decreases are calculated based on the ten year marketing forecast for FM & TS revenue projected from factory production. This approach removes sources of revenue not directly attributable to products manufactured in the FM & TS production facilities addressed in the ITM Project 80.

14.2 ITM Project 80 Cost Drivers

The following paragraphs describe the cost drivers for ITM Project 80.

Direct Labor Savings

The "As-Is hours expended in direct labor which represent assembly hours were taken from the 1986 operations matrix developed during the project

for each of the areas in FM & TS. The workstation productivity improvement factor from the EMPF study (22%) was applied to arrive at the "To-Be" condition.

Savings for the years 1989 through 1999 were projected by using the FM & TS revenue growth factor multiplied by appropriate wage rate. Hourly rates, burden, and escalation percentages were obtained from Honeywell's Cost Estimating department.

Group Leader Savings

The annual hours expended by group leaders were assumed to be constant over the project period (headcount assumed to be one for the card/device area and two for the targeting area). More accurate material location through the use of VS/RS and relayout of the area are the principal factors in reduction of activity. Material related efforts are estimated to be reduced to a maximum of ten percent of normally expended hours.

Hourly rates, burden, and escalation percentages were obtained from Honeywell's Cost Estimating department .

Production Control Savings

The annual hours for production control activities was assumed to be constant over the project period (headcount assumed to be six for Flight Management and four for Targeting Systems). More accurate material location through the use of VS/RS and relayout of the area are the principal factors in reduction of activity. Material related efforts are estimated to be reduced by one-third (from approximately thirty percent to twenty percent of total hours).

Hourly rates, burden, and escalation percentages were obtained from Honeywell's Cost Estimating department.

14.3 Capital and Expense

The capital, recurring and non-recurring expenses for Project 80 are shown in Figure 14.3-1.

14.4 Project Savings and Cash Flows

The savings to be realized in this project exceeds Honeywell's Military Avionics Division hurdle rate. The Project's cash flows are shown in Figure 14.4-1 with the assumption that capital will be available per the implementation plan.

PROJECT 80 EXPENDITURE SUMMARY

	GROSS COST	CAPITALIZATION YEAR
CAPITAL COSTS		
MACHINERY COST		
AREA PREP. (HI)	$161,888	1989
VS/RS UNITS	$43,347	1987
VS/RS UNITS	$53,314	1988
SUB-TOTAL	$258,549	
FURNITURE COST		
MATERIAL CARTS	$11,590	1988
WORKSTATIONS	$69,540	1988
SUB-TOTAL	$81,130	1988
COMPUTER COST		
MAT'L LOCATOR SYS	$26,657	1988
SUB-TOTAL	$26,657	1988
	$43,347	1987
	$161,101	1988
	$161,888	1989
TOTAL CAPITAL COST	$366,336	

	GROSS COST	YEAR EXPENSED
EXPENSE COST		
NON-RECURRING EXPENSES		
AREA PREPARATION (HI)		
	$456,779	1989
SUB-TOTAL	$456,779	
TRAINING		
	$3,100	1989
SUB-TOTAL	$3,100	
PROCESS MODIFICATION		
	$1,500	1988
	$4,000	1989
SUB-TOTAL	$5,500	
VS/RS PROGRAMMING		
	$2,500	1989
SUB-TOTAL	$2,500	
	$1,500	1988
	$466,379	1989
TOTAL NON-RECURRING COST	$467,879	
TOTAL CAPITAL AND NON-RECURRING	$834,215	
RECURRING EXPENSES		
ANNUAL MAINTAINANCE	$9,500	

Figure 14.3-1 Project 80 Expenditure Schedule

	1987	1988	1989	1990	1991	1992	1993
Capital	$43,347	$161,101	$161,888	$0	$0	$0	$0
Non-Recurring Expense	$0	$1,500	$466,379	$0	$0	$0	$0
Recurring Expenses	$0	$0	$0	$9,500	$9,500	$9,500	$9,500
Savings	$0	$0	$134,315	$362,897	$473,972	$556,321	$675,652
Depreciation	$4,335	$19,180	$44,119	$53,903	$45,540	$38,851	$30,833

	1994	1995	1996	1997	1998	1999	TOTAL
Capital	$0	$0	$0	$0	$0	$0	$366,336
Non-Recurring Expense	$C	$0	$0	$0	$0	$0	$467,879
Recurring Expenses	$9,500	$9,500	$9,500	$9,500	$9,500	$9,500	$95,000
Savings	$814,053	$946,074	$1,064,499	$1,146,021	$1,251,711	$667,528	$8,093,043
Depreciation	$24,763	$22,825	$24,189	$22,728	$19,470	$15,600	$366,336

Figure 14.4-1 Project 80 Cash Flows

SECTION 15

IMPLEMENTATION PLAN

The implementation plan for ITM Project 80 initially developed out of an earlier review of factory requirements and the recognition of a need to initiate modernization activities within the FM & TS Production area. ITM Project 80 concentrated attention on improvements which could be made in material handling methods and area relayout within the FM & TS Card and Device Test/Assembly Production areas.

Since the equipment and facilities proposed for acquisition are readily available from several vendors, implementation can be accomplished within a relatively short period (under six months) and will be paced by the availability of physical facilities.

15.1 Implementation Plan Activities

Implementation of ITM Project 80 activities is depicted in the Plan Schedule (Figure 15.1-1). The improvements scheduled for ITM Project 80 include the following:

- Relayout and relocation of the FM & TS areas
- Installation of Vertical Storage and Retrieval Systems
- Implementation of VS/RS Putaway/Locator System
- Purchase and use of Dedicated Material Handling Carts
- Restructuring of group leader and production control activities
- Purchase and use of Modular Workstations

The availability of factory floor space will allow installation of the improved product flows as well as the planned operational parameters for the improved equipment.

ITM Project 80 implementation will take place in three basic phases:

Phase	Activity
I	Program Planning
II	Acquisition, Installation, and Training
III	Operation and Validation

15.2 Phase I - Program Planning

During this phase, all documentation relating to purchasing of the equipment and/or software should be finalized. This will permit immediate initiation of purchase orders upon project approval.

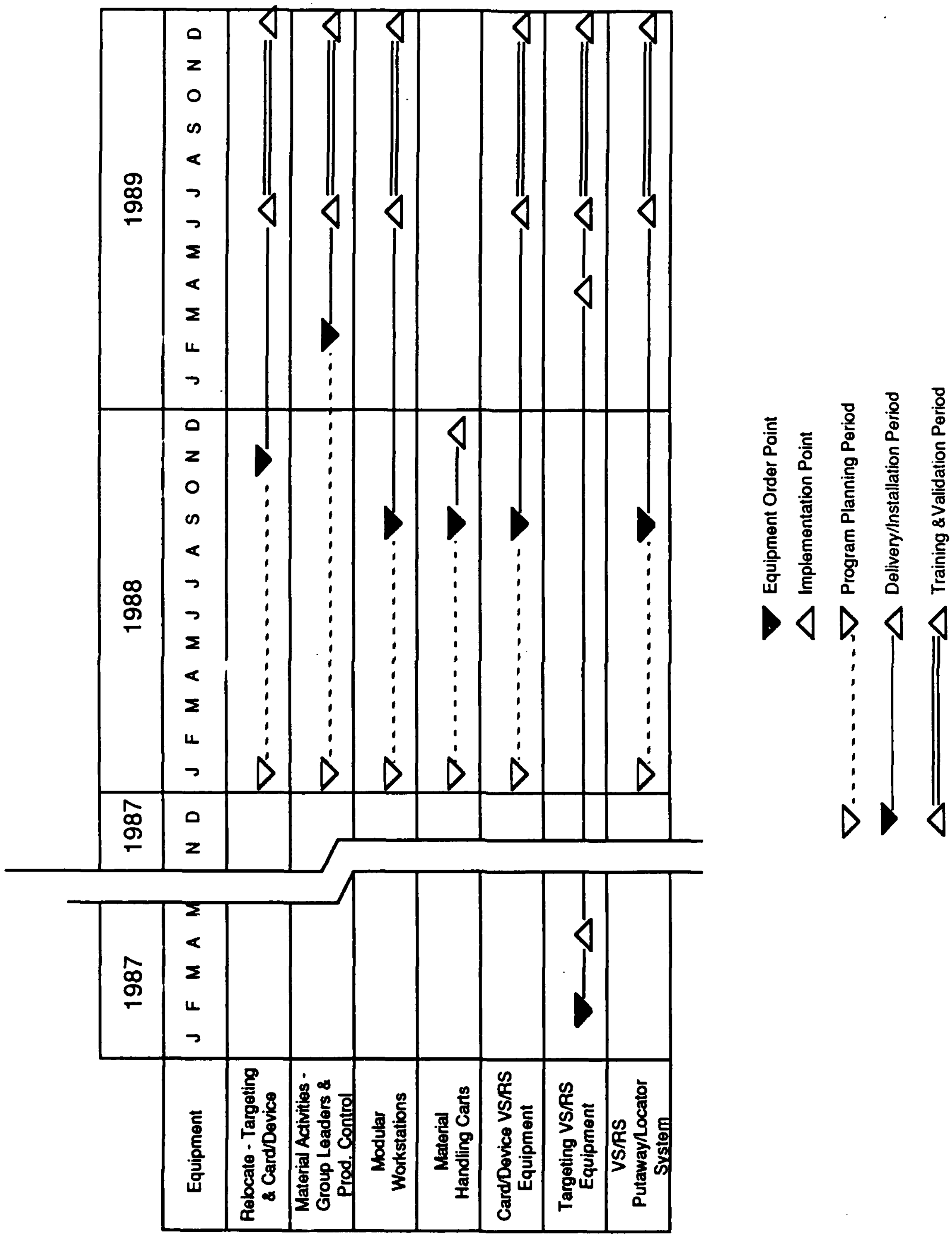


Figure 15.1-1 Project 80 - Implementation Plan

15.3 Phase II - Acquisition, Installation, and Training

Upon placement of orders, physical preparations can commence.

Sufficient time is available to stabilize equipment locations which fit into revised areas and product flows and make adjustments in processes and methods which will more effectively integrate the new equipment.

Prior to installation at Honeywell, all software systems will be validated at the respective vendors. All parameters which are customized to Honeywell's requirements will be functionally demonstrated before delivery.

15.4 Phase III - Implementation and Validation

Implementation is dependant upon the relocation and relayout effort associated with this project. Due primarily to capital availability, the relayout/relocation will not begin until the first quarter of 1989. It is assumed that all necessary documentation changes associated with the scheduled build of principal models will be completed prior to the start of this phase. This will permit an accurate measurement of the benefits of each improvement and validation of the project savings.

Since the implementation of nearly all the modifications in ITM Project 80 impact direct labor performance, the principal validation in the "To-Be" organization will be derived from the "Foreman's Cost Control" records on a month-by-month basis. Additionally, time studies evaluating selected standards may be conducted to validate projected values. Revised paybacks can then be estimated with the resulting "live" data.

SECTION 16

PROBLEMS ENCOUNTERED AND HOW RESOLVED

Problem: Availability of space for ATE Central facility to be located with FM & TS area upon project implementation.

Solution: *Chassis area was combined* with the relocated transformer facility inside the clean room area.

Problem: Translating various FSO marketing projections of future revenue into growth figures applicable to FM & TS.

Solution: Figures were ultimately subjected to a process of review and scrutiny to ascertain those actually applicable to FM & TS Production.

Problem: Preliminary designs, while technically correct, did not reflect FM & TS preferred operational mode.

Solution: Subsequent designs were modified in a "working meeting" atmosphere so as to contain a maximum number of features desired by the operational personnel who would be implementing and using them.

Problem: Large quantities of parts related data presented a significant data reduction task to derive usable summaries.

Solution: Large data matrices were developed to integrate product description, operation, standards, and quantity data. This enabled accurate and comprehensive summaries to be developed.

Problem: Multiple locations were potentially available for future operations necessitating significant relayout efforts.

Solution: Area elements were entered into CAD database allowing easier update and *relayout as revisions and relocations were proposed.*

Problem: Significant amounts of tabular data developed and continually modified to reflect current rates, times, and quantities. This was potentially a large clerical task.

Solution:	Data was linked and manipulated via powerful spreadsheet programs thus minimizing clerical effort.
Problem:	Initial FM & TS area allowances provided insufficient space for Targeting Systems area and no expansion room.
Solution:	Different location was designated to allow for both Targeting Systems expansion plus inclusion of DEPRT program.

SECTION 17

AREA FOR FUTURE CONCERNS/DEVELOPMENT

Future Concerns

- As implementation of Factory Data Collection (FDC) is considered and initiated, attention should be given to providing only those data elements which are necessary for specific area functions to be available in that area. This will reduce the "clutter" of data which could potentially impede the performance of the system. This, essentially, is the essence of hierarchically linking work centers, cells, stations, etc. so that each node has the key resources necessary to accomplish its task.

- Equipment has been proposed for this project in which capabilities exist for future inclusion in local factory networks. This will facilitate future factory modernization. It is important that any automated equipment under consideration be viewed as necessarily including this capability.

Future Development

- Any replacement equipment should have the capability to interface or network so that data can be exchanged and configuration can be controlled.

- FM & TS should continue to advance the requirement for "design for manufacture" to facilitate future cost reductions.

- Continuous evaluation of equipment coming into the marketplace will uncover price-performance "breakthroughs" that signal a cost effective solution to earlier, uneconomic alternatives.

- Work area arrangements should be sensitive to product volume and models to take advantage of the largest potential savings.

- FM & TS should resist any future considerations for "splitting up" card and device or IHADSS (Intergrated Helmet and Display Sight System) activities, thus avoiding increased material handling costs and re-introducing production inefficiencies.